1965

A study of marked sand movement on Del Monte Beach, Monterey Bay, California

Hohenstein, Clyde Gilbert; Jaeger, James Walter; Jones, David Lynn

Monterey, California. Naval Postgraduate School

A STUDY OF MARKED SAND MOVEMENT ON DEL MONTE BEACH, MONTEREY BAY, CALIFORNIA

CLYDE GILBERT HOHENSTEIN,
JAMES WALTER JAEGER
and
DAVID LYNN JONES

A STUDY OF MARKED SAND MOVEMENT

ON DEL MONTE BEACH,

MONTEREY BAY, CALIFORNIA

* * * *

Clyde Gilbert Hohenstein

James Walter Jaeger

and

David Lynn Jones

A STUDY OF MARKED SAND MOVEMENT
ON DEL MONTE BEACH,
MONTEREY BAY, CALIFORNIA

By

Clyde Gilbert Hohenstein

Lieutenant, United States Navy

James Walter Jaeger

Lieutenant, United States Navy

and

David Lynn Jones

Lieutenant, United States Navy

Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE

United States Naval Postgraduate School
Monterey, California

1965

A STUDY OF MARKED SAND MOVEMENT

ON DEL MONTE BEACH,

MONTEREY BAY, CALIFORNIA

by

Clyde Gilbert Hohenstein

James Walter Jaeger

David Lynn Jones

This work is accepted as fulfilling

the thesis requirements for the degree of

MASTER OF SCIENCE

from the

United States Naval Postgraduate School

ABSTRACT

The movement of fluorescent-coated sand on Del Monte Beach, Monterey Bay, California was traced for a three-week period during February and March, 1965. In order to speed analysis of hundreds of sediment samples, a rapid volumetric measurement was developed to replace the standard weight measurement in textural analysis. Marked sand grains in different size ranges were found to move in different directions, both along and across the beach. No dominant longshore drift occurred. The observed movement of the sand correlated with the natural sand texture, beach profile changes, and the presence of cusps.

TABLE OF CONTENTS

LIST OF TABLES

LISTS OF FIGURES AND PLATES

1. INTRODUCTION

The topic of sand movement on sand beaches is not new in the published literature; nevertheless, this literature is not abundant. Considerable advances have been made in the past decade, with the introduction of various types of artificial tracers, particularly radioactive grains and luminifors. Luminifors, developed in the U.S.S.R., have proved most useful because of low cost, ease of production, public acceptance, and durability.

The Study

F. F. Wright at Columbia University and J. C. Ingle at the University of Southern California appear to have conducted the most recent studies on the movement of fluorescent-marked sand on beaches (Wright, 1962, and Ingle, 1962). Both of these studies were carried out on beaches which exhibited pronounced littoral drift. They were also very temporal, lasting only several hours. It is of interest to note that Timme and Pollard of National Marine Consultants, Anaheim, California, are currently conducting periodic luminifor seeding in Orange County, California, for the purpose of studying littoral drift, but no results have been published.

In contrast to these studies, this investigation was carried out using fluorescent-marked sand on a beach which

is known to exhibit little or no littoral transport of material. The principal sand movement on Del Monte Beach, in southern Monterey Bay, is believed to be almost entirely in the form of offshore-onshore movement, accompanied by lateral diffusion. Thus, this beach represents a special environment which merits investigation. In the study described herein, a single emplacement of marked sand, extending between the high and low tide lines, was made on the beachface. The movement and concentrations of marked grains in various grain-size intervals were then determined from eleven field surveys conducted over a three-week period. The study was restricted to the intertidal zone. The results, confirming the absence of any significant littoral drift during the observation period, and some laboratory techniques devised for handling and analysis of large numbers of sand samples are presented.

The Beach

Del Monte Beach lies at the southern end of a long, uninterrupted sand beach extending from the head of Monterey Canyon at Elkhorn Slough to a bulkhead alongside Monterey Municipal Wharf Number 2, a distance of approximately fourteen miles. Its gentle curvature, as shown in Figures 1 and 2, approximates the logarithmic spiral that Yasso (1964) has found on several similar headland-protected beaches.

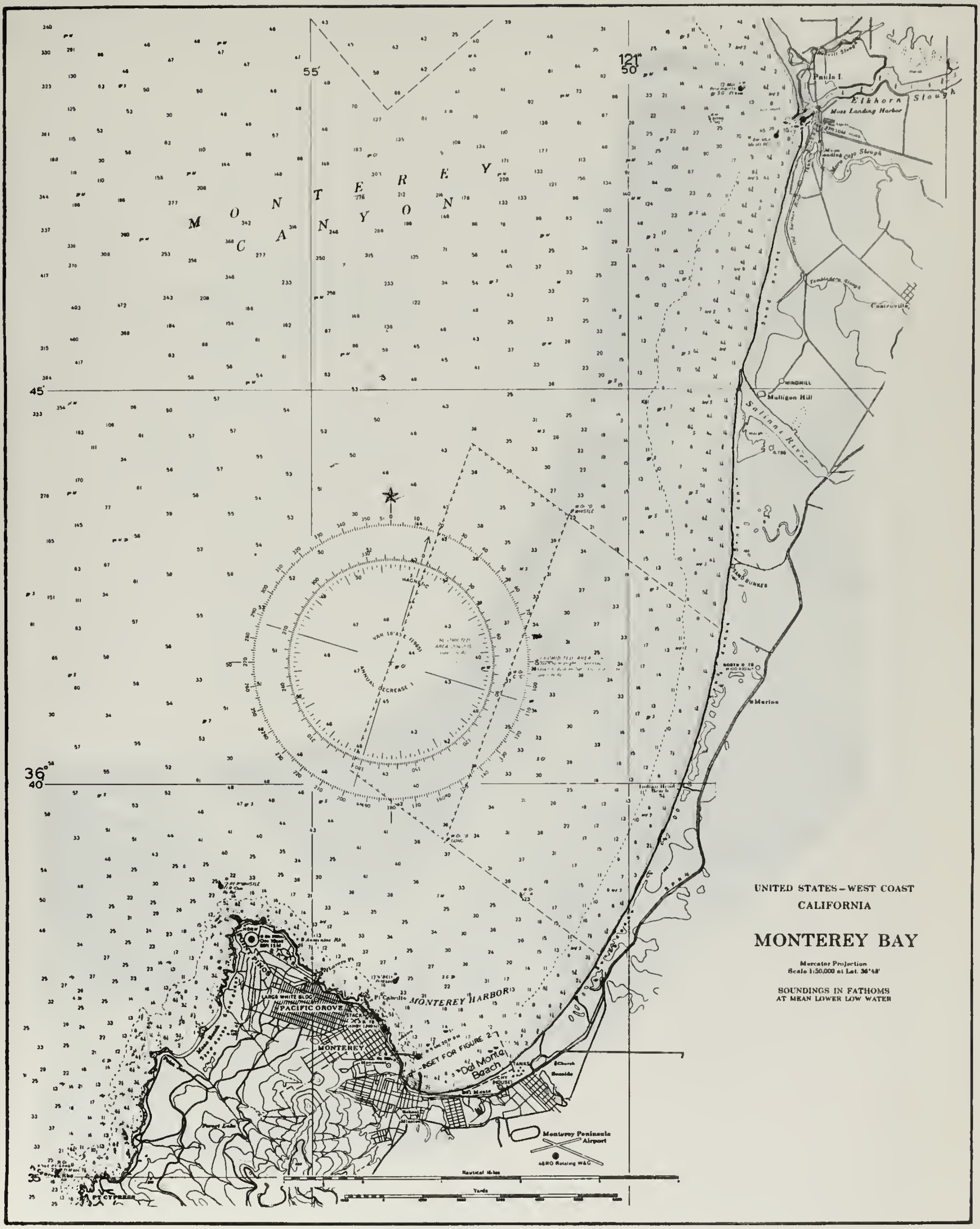


FIGURE 1
SOUTHERN MONTEREY BAY

FIGURE 2
DEL MONTE BEACH

The slope of the beach is moderate to gentle and the sand dominantly quartz and feldspar, having a medium to fine texture.

The beach is normally well protected from storm-wave attack by the Monterey Peninsula. Waves arriving from the open ocean are refracted to such an extent that the breaker height is typically low and the breaker angle is nearly always very small or zero. Accordingly, longshore currents are ordinarily negligible and rip systems are characteristically weak or absent (Brennan and Meaux, 1964). The beach profile responds sensitively to daily changes in wave properties, with significant profile changes occurring frequently (Koehr and Rohrbough, 1964). The absence of any significant littoral drift in the immediate area of the study, shown in Figure 3, is indicated by the absence of pronounced progradation or erosion adjacent to the bulkhead alongside Wharf Number 2 since its construction in 1960.

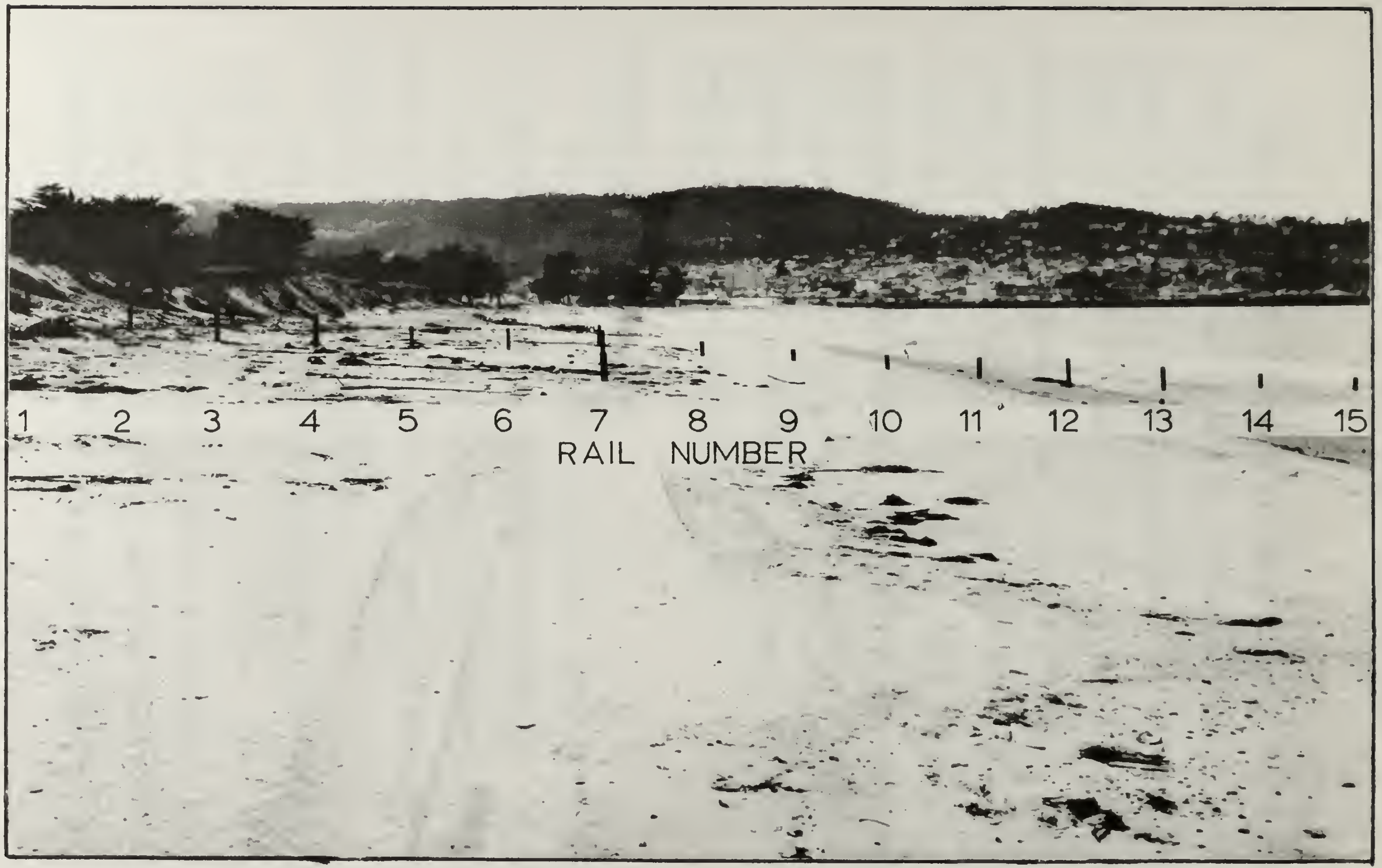


FIGURE 3
DEL MONTE BEACH AT PROFILE B

2. FIELD PROCEDURES

On the basis of work by Yasso (1962) and Ingle (1962), it was decided that the most suitable marked sand for the study would be fluorescent-coated. It was felt that in order to adequately describe the motion of all sand sizes naturally occurring on the beach, the marked sand grains should be present in all sizes in sufficient numbers that their concentrations could be measured in samples to be collected from the beach. The coating of sand taken from the beach would have produced a sand distribution with high concentrations of grains in phi sizes 1 to 3 and very low concentrations outside this range.

Marked Sand Procurement

In order to produce a suitable grain-size distribution, an artificial mixture of sand was prepared. Local commercial sources derive their sand from coastal dunes and from the sea floor within the surf zone. Sand from two such commercial sources was blended.

The resulting sand mixture was then coated by the Great American Color Company in Los Angeles. Two colors, fluorescent red and fluorescent yellow, were used. These colors are easily distinguishable from each other and from natural fluorescence under ultra-violet stimulation. The size

[illegible]

[illegible]

[illegible]

[illegible]

distribution of the red and yellow sand is shown in Table I and in Figure 4.

Emplacement of Marked Sand

The site selected for emplacement of the marked sand was at Profile B on the western end of the U. S. Naval Postgraduate School property on Del Monte Beach. Profile B, shown in Figure 3, installed for another study, consists of a series of rails driven into the sand at intervals of twelve feet across the beach. The profile provided a convenient location because it served as a reference system for across-the-beach distances and provided the source of the daily beach profile measurements which were used in interpreting the marked sand distribution.

A grid system, based on 50-foot squares, was established as illustrated in Figure 5. Wooden stakes were driven into the sand at 50-foot intervals along the rear of the beach on a line through Rail 1 of Profile B, in order to establish the position of grid "columns." The distance across the beach to the various grid "rows" was measured by means of a marked line. The grid was 1000 feet long, 150 feet wide, and centered on Profile B. The seaward row extended further into the surf zone at the western end of the grid because the beach narrows slightly to the west.

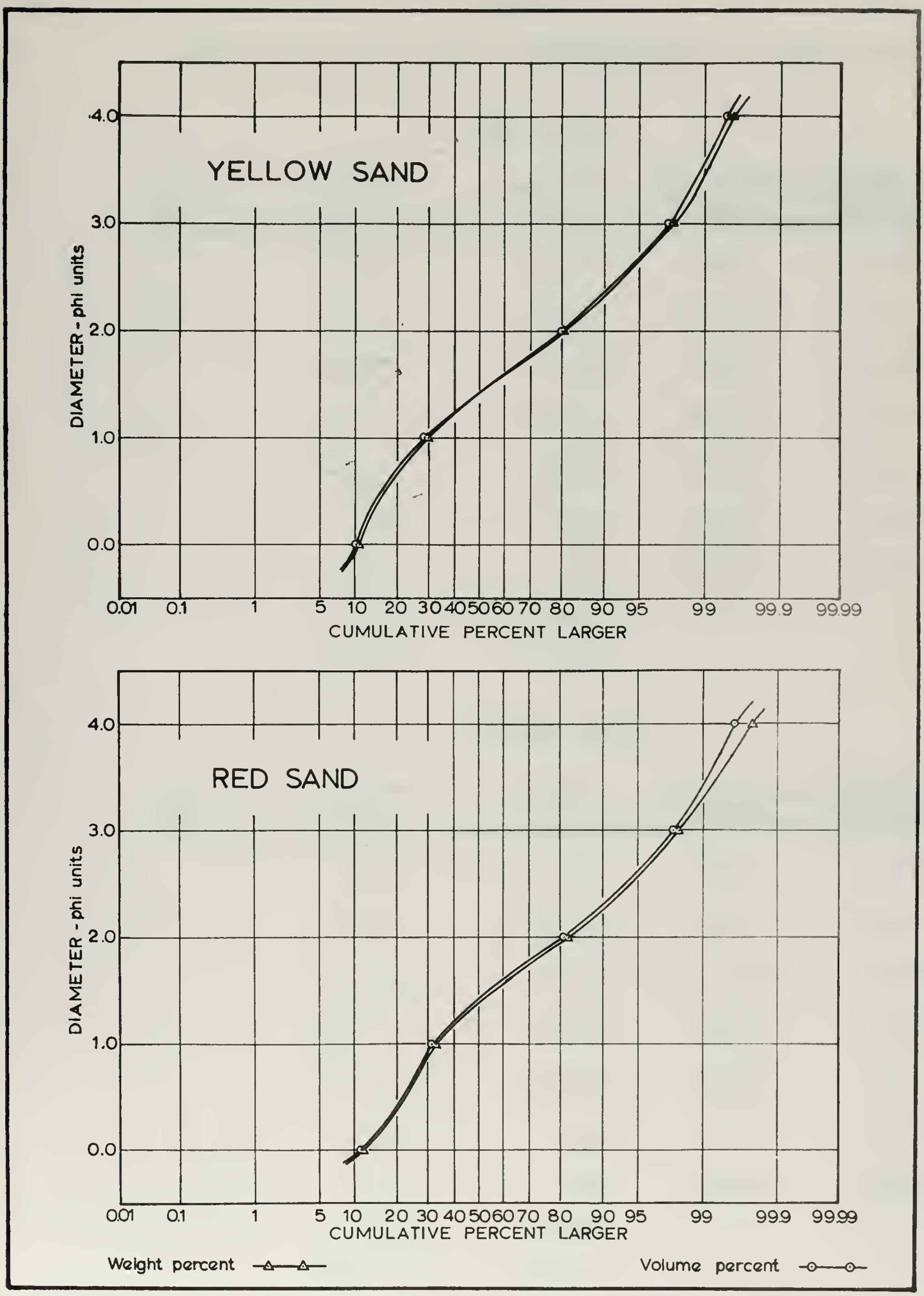


FIGURE 4
CUMULATIVE FREQUENCY CURVES
OF MARKED SAND

TABLE I

CUMULATIVE GRAIN-SIZE DISTRIBUTION OF MARKED SAND

RED SAND

Size (Φ)	Volume (ml.)	Weight (g.)	Cumulative Percent Volume	Cumulative Percent Weight
	0.0	0.0	0.0	0.0
-1				
	11.1	17.89	11.44	11.70
0				
	19.78	32.38	31.83	32.88
1				
	48.1	75.15	81.41	82.02
2				
	15.9	24.56	97.79	98.08
3				
	1.75	2.57	99.60	99.76
4				
	0.39	0.36	100.00	100.00
	97.02	152.91		

YELLOW SAND

Size (Φ)	Volume (ml.)	Weight (g.)	Cumulative Percent Volume	Cumulative Percent Weight
	0.0	0.0	0.0	0.0
-1				
	22.9	37.83	10.51	10.88
0				
	40.15	65.42	28.94	29.68
1				
	111.7	177.91	80.20	80.83
2				
	37.5	58.37	97.42	97.61
3				
	4.47	6.80	99.47	99.56
4				
	1.16	1.53	100.00	100.00
	217.88	347.86		

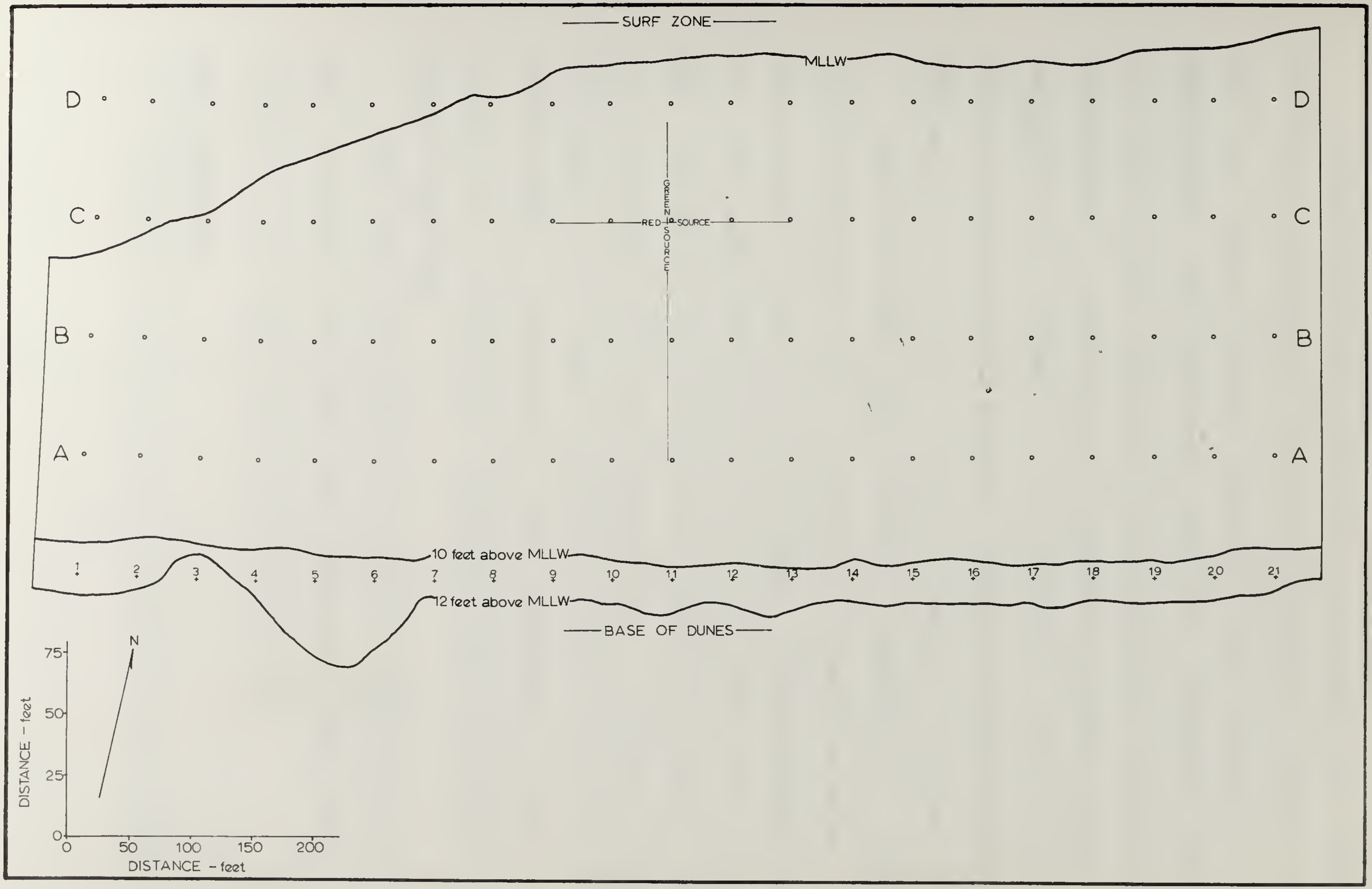


FIGURE 5
INITIAL GRID

It was decided to emplace the two colors in a configuration that might help separate longshore movement from onshore-offshore movement during the early stages of the experiment. The colors were placed on orthogonal lines. One line extended across the beach, parallel and adjacent to Profile B. This line was expected to better reflect longshore sand movement. The second line, parallel to the beach, was expected to reflect onshore-offshore motion. The positions of these two lines is shown in Figure 5.

The fluorescent sand was sown on February 20, 1965, in the intertidal zone at the time of lower low water on the exposed portion of the beachface. Three-hundred pounds of yellow sand were spread in an 18-inch wide path, extending from 50 to 190 feet from the rear of the beach, parallel to and two feet west of Profile B. A similar path of 214 pounds of red sand was placed 150 feet from the rear of the beach, perpendicular to and extending 100 feet on either side of Profile B. The marked sand was evenly spread with a lawn rake.

The sowing was completed at 0900. During the following six hours, both paths were submerged by the rising tide, except for the upper end of the yellow line.

Sand Sampling

A sampler was devised by cutting 3½-inch ID Lucite

tubing into 4½-inch lengths. In collecting samples, the tube was pressed into the sand for its full length whenever possible. The sand sample was then placed with an identifying tag in a polyethylene bag. The cross-sectional area of this tube, 9-3/5 square inches, was the unit area upon which the results of this study are based.

Prior to emplacement of the marked sand, a series of 21 samples was drawn from the beach at the mid-tide level, at ten 50-foot intervals either side of Profile B. These samples were used to investigate background fluorescence of the natural beach sand, and to test the validity of using volume percentages in place of weight percentages in determining fractions of a sand sample. The results of these investigations are discussed in Section 4. Median diameters and sorting coefficients for the natural beach sand as derived from these samples are presented in Appendix A.

Following emplacement of the fluorescent sand, samples were drawn in 11 separate runs over a three-week period. The date and time of each run and the number of hours which elapsed following seeding are listed in Table II.

In an attempt to make each run synoptic, the authors collected the samples as quickly as possible. Sample spacing for the first nine runs was 50 feet. This spacing was increased during the last two runs because of sand

TABLE II

RUN SCHEDULE

Run	Date	Time	Hours after Emplacement	
Emplacement	20 February	0900	0.0	
1	20 February	1010	1.2	
2	20 February	1115	2.2	
3	20 February	1315	4.2	
4	20 February	1520	6.3	
5	20 February	1630	7.5	
6	21 February	0945	25	(1.0 days)
7	21 February	1650	32	(1.3 days)
8	22 February	0940	49	(2.0 days)
9	27 February	1405	173	(7.2 days)
10	6 March	0620	333	(13.9 days)
11	13 March	1430	510	(21.2 days)

dispersion along the beach. Field sampling was terminated after three weeks, when sample analysis indicated that marked grain concentrations were so low that continued field sampling would yield little additional information. The marked sand concentrations determined for each run are plotted on common charts of the beach in the plates at the end of the thesis.

3. LABORATORY PROCEDURES

The laboratory analysis of sand samples consisted principally of counting the marked grains occurring in each grain-size class of the sample. This required a visual examination of each grain-size class in more than six hundred samples. In order to handle such a large number of samples in a reasonable length of time, attention was given to devising quick methods.

The processes involved in the analysis of a sand sample in order to obtain a marked grain count were (1) drying, (2) measurement of a representative portion, and (3) counting of marked grains. A description of these processes, of the experimentation involved, the difficulties encountered, and the ideas and techniques which expedited sample analysis are presented below. Data resulting from the sample processing are presented in Appendix B.

Drying Samples

An effort was made to circumvent the ordinarily time-consuming process of drying large numbers of sand samples by making grain counts on moist sand. However, drying was found necessary after two methods of counting marked grains in a damp sample proved unsatisfactory.

The first method involved spreading the moist sample into a thin layer and removing the marked grains individually as they were observed under the ultra-violet light. Removal was required for later determination of grain size. In addition to the annoyance arising from the tendency of moist grains to adhere to the spatula and to one another, the method was found excessively time-consuming and impossible in samples containing hundreds to several thousands of marked grains.

A second method was attempted wherein an entire sample was spread in a large, shallow tray and covered with water. The sand was agitated until most of the grains were in suspension, then allowed to settle in a smooth, thin layer. There were three difficulties. First, the samples were too large for the tray, and many of the grains were buried. Second, the great number of fluorescent grains in many of the samples precluded accurate counting. Finally, the water surface reflected much of the ultra-violet and violet light from the ultra-violet lamp, resulting in undesirable eye strain during the counting process.

As a result of these unsuccessful methods of determining the marked grain count, it was concluded that each sample would require desiccation prior to further processing. The initial drying method used was natural drying,

i.e., exposing the samples to room temperature and normal ventilation. This method produced dry samples, but required a large area over which to spread samples and a drying time on the order of weeks. Inasmuch as space and time were limited, the natural drying technique was undesirable and subsequently discarded.

Small quantities of marked sand were then placed in a drying oven to determine if forced drying would cause deterioration of the fluorescent color or flaking of the coating. No detrimental effects were noted for exposures of 72 hours at 250° F. Subsequently, most samples were subjected to forced drying at 190° F if dried overnight, or 230° F if the drying time was to be less than five hours.

The sand samples which were force dried became encrusted and caked by salts and the clods required breaking up before further processing. This was accomplished by rolling a wooden dowel over the samples, using a thick pad of paper as the rolling surface to avoid grinding individual grains.

Measuring Samples

The size of the samples and the potentially large number of marked grains in each precluded analyzing entire samples. It was necessary to count the marked grains in a small portion (split) of each sample, then correct this

count to determine the number of marked grains in the sample.

The standard method of determining the portion of a sample that is represented by a split is by weighing. However, weighing each sample and split on an analytical balance was too time-consuming. The weighing was replaced by a rapid volumetric measure that was found to yield sufficiently accurate determinations of the ratio of sample size to split size. The amount of sand composing a sample or split was measured in a graduated cylinder. In order to obtain reproduceable measurements, the graduate was tapped until the dry sand column would settle no further.

Before proceeding with the analysis of the large number of samples collected, the accuracy of replacing weight fractions with dry volume fractions was determined by comparative textural analysis of samples by both methods. Eleven samples, one each of the two colors of marked sand and nine samples taken from the beach, were selected. The results of this test are presented in Table I and Figure 4 for marked sand, and Appendix C for the other nine samples. On the basis of this test, the volumetric measure was adopted.

After drying and measuring each beach sample, splits of approximately 12 milliliters were prepared by repeatedly

passing the sample through a Jones splitter. The split volume was measured as outlined above. The splits were then shaken through a nest of six sieves selected to divide the split at the Wentworth phi sizes -1, 0, 1, 2, 3, and 4. Since two sets of sieves were available, the shaking time was determined by the time required to count the marked grains in the previous split and record the numbers. The usual shaking time was seven to ten minutes, with each split being shaken at least five minutes.

Counting Marked Grains

In preparation for the identification and counting of marked grains in the beach samples, an investigation was made of the fluorescence of natural grains on the beach. The twenty-one samples collected prior to emplacement of the marked sand were examined under ultra-violet light to determine the color and intensity of natural fluorescence. Fluorescent grains were found to be common; however, they caused no confusion because their color and intensity were much less pronounced than that of the marked sand.

After the sieving, the marked grain count in each split was made. The nest of sieves was taken into a darkened room where each sieve was emptied in turn and its contents spread into a layer one grain thick. The

fluorescent grains were excited by a portable ultra-violet light, and the number of marked grains in each grain size-color combination noted.

In order to ensure that each grain counted was indeed a marked grain, especially in samples containing few or no marked grains, frequent visual reference was made to small pans containing red and yellow marked sand. This system allowed detection of marked grains in concentrations as small as one in 100,000, with little possibility of counting naturally fluorescent grains.

During the counting process, safety glasses or reading glasses were worn. Before adopting this eye protection, two of the authors received superficial eye burns from reflected ultra-violet light. It is felt that the glasses caused no loss of color discrimination.

4. DATA PROCESSING AND HANDLING

Before the data processing of grain counts could proceed, it was necessary to decide which of two ways the marked grain concentrations should be expressed: by the number of marked grains in a unit volume, or by the number of marked grains under a unit area of beach. The data handling differences would have been minor, but the difference in concept is major.

Units of Grain Concentration

Consider a situation in which marked grains are uniformly distributed vertically through a substantial thickness of the beach, and a sand sample is extracted using a sampler which penetrates only a fraction of the distance to the base of the layer containing the marked grains. A sample of any size would thus give a correct measure of the concentration if the concentration were expressed by the number of grains per unit volume; however, it would give an incorrect measure of the number of grains per unit area because additional grains lie below the depth of the sampler. If the grains were not uniformly distributed vertically throughout the thick sand column, a sample would not necessarily yield a useful measure of the concentration in terms of volume.

The mixing of marked grains through a thick sand column is possible as a result of changes in the beach profile caused by changing wave conditions. On Del Monte Beach, where littoral drift is minimal and marked grains may after a period of weeks or months become mixed throughout a considerable thickness of the beach by offshore-onshore sand movement, the concentration of marked grains would probably be expressed most accurately in terms of fluorescent grains per unit volume.

Consider, on the other hand, a situation in which the marked grains are concentrated within a very thin layer on or within the beach, and the sand sampler that penetrates the layer also retrieves sand from barren zones below or above the layer. In this case, the number of marked grains expressed in terms of volume would be incorrect; however, the concentration would be correctly described by the number of grains per unit area.

If the sampler did not penetrate the layer containing marked sand, neither method of expressing the concentration would be correct. For a short-term study, lasting several hours, during which the amount of accretion or erosion on the beach is usually small, the concentration may be most accurately described by the number of grains per unit area. Ingle (1962) expressed his concentrations in this manner.

The present study was of moderate duration. Complete vertical mixing could not be assumed, nor could beach profile changes be ignored. It was decided to sample the beach to a significant depth and to express the grain concentration on a unit-area basis. The sampler was assumed to have passed through the entire layer in which marked sand might have occurred. The validity of this assumption rests on the length of the sampler (4 inches) relative to the range of sand elevations on the beach during the study. The maximum change in the beach profile was on the order of one foot.

Data Reduction and Presentation

A quick, simple method of data processing was required to handle the information derived from the 625 samples. The U. S. Naval Postgraduate School's Control Data Corporation 1604 computer was programmed to reduce and plot the sample data. The basic data, as read into the computer, are listed in Appendix B. Grain concentrations per unit area were calculated by multiplying the number of marked grains counted in each phi range-color pair by the ratio of sample volume to split volume. These calculations were completed separately for each run, and the results were printed on a schematic diagram of the grid which had been programmed.

Initial contouring of the printed values was done on the computer-produced grid. These contours were transferred to a chart of the beach adapted from charts prepared by the San Francisco District office of the U. S. Army Corps of Engineers. The chart was given a north-south exaggeration of two, widening the beach with respect to its length. The results are presented in Plate Series 1 through 5 at the end of the thesis.

The contours of Runs 1 through 5 were drawn to a model which assumed that the highest concentrations of red and yellow sand lay along the source lines. This model was disregarded after Run 5 since sand elevation changes indicated that the line sources had dispersed and the centers of maximum concentration had moved. Separate concentration contours for red and yellow sand were used for Runs 1 through 9. In Runs 10 and 11, the contours show the combined number of red and yellow grains in each phi range; this was desirable because of the dearth of marked grains found during these two runs.

In addition to concentration information, each plate presents the run number, phi range, and interval of time since sowing. The tide stage and height preceding the run is also shown. The source lines are presented on each plate to aid the reader in referring concentration contours to the initial placement of the marked sand.

5. OBSERVED SAND MOVEMENT

For ease of examination, the plates containing the marked grain concentrations were organized to show the concentration changes for each phi range beginning with the very coarse sizes. The first part of each hyphenated plate number indicates the phi range and the second part indicates the run number. In the singular case of the very coarse grain size, Plates 1-1 to 1-5, this organization was not used because of the lack of data.

Synopsis of Runs

Runs 1, 2, and 3

Runs 1 through 3, shown on Plates ()-1, ()-2, and ()-3, were made during the first 4.2 hours after emplacement of the marked sand. During this period, the tide was rising, reaching Row A of the sample grid by the time of Run 3. Throughout the period, the marked sand remained in one well-defined concentration centered on the source lines. It is apparent that diffusion was the principal dispersing agent.

As revealed by the yellow sand, there was a tendency for coarse grains to drift eastward, and for very fine grains to move westward. Medium and fine grains were distributed symmetrically on either side of the source line.

Onshore-offshore movement of marked sand, traced by transport away from the red source line, was limited to grains larger than very fine. All other grain sizes moved up the beach with the rising tide.

Runs 4 and 5

Runs 4 and 5, shown on Plates ()-4 and ()-5, were made from 6.3 to 7.5 hours after seeding, following a lower high tide which wetted the entire sample grid. Although the sand was spread further because of the increased dispersal time, the highest concentrations remained in the vicinity of the source lines.

An eastward longshore movement of all grain sizes was found. Very fine grains reversed their initial westerly movement, medium and fine grains moved eastward, and the coarse grains accelerated their easterly drift.

Coarse and medium grains continued to move onshore from the red source line. Much of the sand in the fine and very fine grain sizes also moved onshore, but there was as well some movement offshore into the surf zone seaward of the sample grid. This offshore movement was distinctly linear, and was centered at the yellow source line.

Runs 6, 7, and 8

Runs 6, 7, and 8 were made during the period from 24 to 48 hours after emplacement of the marked sand and

are shown in Plates ()-6, ()-7, and ()-8. Marked sand distributions during these runs were patchy, but the concentrations remained high. The principal concentrations were found near the source lines, with occasional centers of concentration appearing as far away as 500 feet. The higher high tides which occurred after Run 5 began to disperse the fine and medium sand in the upper end of the yellow source line.

There was a weak eastward longshore drift of all grain sizes. This drift was especially evident in the very coarse grain sizes during Runs 7 and 8, and in the distribution of the marked sand from the persistent concentration center located at the upper end of the yellow source line.

The onshore-offshore motion of coarse and very coarse sand could not be determined because of the paucity of data. Medium, fine, and very fine grains were moved onshore after Run 5, and were found during Run 6 at the back of the beach. For the next 24 hours, through Runs 7 and 8, this sand remained at the back of the beach.

Run 9

Run 9, made one week after sowing, is shown on Plate 1-5 and Plates()-9. The distribution of all sand sizes was very patchy, with indications of a cyclic

occurrence of high concentrations along the beach. Marked sand had dispersed beyond the limits of the sample grid to the east and west, and extended seaward of the grid as well.

After the first week of dispersion, the medium and fine sand sizes showed no net longshore movement. However, the coarse marked grains were moved eastward, and very fine marked grains moved westward.

There were insufficient data to support conclusions regarding the onshore-offshore movement of coarse and very coarse marked grains. In finer grain sizes, however, the principal concentrations were found at the back of the beach, with more or less evenly spaced bands of moderate concentration extending across the beach.

Runs 10 and 11

Runs 10 and 11 were made two and three weeks, respectively, after seeding. The marked sand distribution found is shown on Plates 3-10, 4-10, 5-10, 3-11, and 4-11. Because the sand had dispersed beyond the initial sample grid, Runs 10 and 11 were plotted on extended grids. Red and yellow grain concentrations were combined during the process of contouring the data.

No coarse or very coarse marked grains were found on Run 10. Medium grains were concentrated near and to the east of the source lines, but low concentrations were

found as far as 2,000 feet to the west. Fine marked grains also were concentrated near and to the east of the source lines, but all very fine marked grains were found to the west, some as far as 2,700 feet from the source lines.

The only marked grains found on Run 11 were in the medium and fine grain sizes. These concentrations were somewhat lower than those found on Run 10, and were located within 500 feet of the source lines. The marked sand tended to remain on the upper part of the beach during both runs.

<u>Movement of Sand in Different Phi Ranges</u>

<u>Phi Range -1 to 0</u> (2 to 1 mm.)

Very few marked grains were found in phi range -1 to 0. Small concentrations were sampled only during Runs 3, 4, 7, 8, and 9. These are shown on Plates 1-1 through 1-5, respectively. Because of the small concentrations, onshore-offshore movement could not be determined; however, there was a tendency for grains in this size fraction to move eastward.

<u>Phi Range 0 to 1</u> (1 to $\frac{1}{2}$ mm.)

The coarse marked sand grains, shown in Plates 2-1 through 2-9, exhibited a very weak but definite migration toward the east throughout all runs, with the exception of Runs 10 and 11 during which no grains in this size range were recovered. Within the first few hours

after emplacement, and with the rising tide, these grains dispersed symmetrically about the yellow source line and moved up the beach. This upbeach transport is well illustrated by the red sand contours on Plate 2-3. As late as Run 8, the upper end of the yellow source line was serving as a source of yellow marked sand. Plates 2-7 and 2-8 suggest that the coarse sand responded to the tide, with upbeach movement occurring during the flooding tide and downbeach movement during the ebbing tide.

Phi Range 1 to 2 ($\frac{1}{2}$ to $\frac{1}{4}$ mm.)

During the rising tide which followed emplacement of the marked sand, the medium grain sizes experienced a pronounced upbeach movement, accompanied by significant lateral diffusion, as shown by Plates 3-1 through 3-3. The distribution pattern remained symmetrical about the yellow source line until Run 4. By Run 4, the symmetry was destroyed by a moderate eastward drift which persisted for the rest of the week. Twenty-four hours after emplacement, medium sand was observed to extend seaward of the sampling grid, as shown on Plate 3-6. On Runs 7 and 8, the principal concentrations of medium grains were found east of the source lines and spread along the middle and back of the beach, as pictured on Plates 3-7 and 3-8. By the time of Run 9, one week after emplacement, the marked sand had spread widely both east and west from

the source lines, but was concentrated along the back of the beach. Two weeks after sowing, at the time of Run 10, the main concentrations remained at the back of the beach and near the source lines. The medium sand had almost disappeared three weeks after sowing, as shown by Plate 3-11.

Phi Range 2 to 3 (1/4 to 1/8 mm.)

The behavior of the fine marked sand was nearly the same as that of the medium sand, as may be seen in Plates 4-1 through 4-11. The major exception is that concentrations were, in general, higher. Of particular interest is the areal distribution found on Run 9, shown on Plate 4-9, which displayed a well-defined periodicity along the beach.

Phi Range 3 to 4 (1/8 to 1/16 mm.)

During the first four hours following the marked sand emplacement, shown on Plates 5-1 through 5-3, the very fine sand moved up the beach on a wide front, as well as seaward in a narrow tongue. The longshore drift was principally westward. By the time of Run 4, six hours after sowing, the longshore movement became easterly, but the seaward tongue persisted. Runs 5 and 6, pictured on Plates 5-5 and 5-6, found very fine sand concentrations centered on the lower beach and extending seaward of the grid. By the time of Run 7, 31 hours

after seeding, the higher tides had disturbed the marked sand at the upper end of the yellow source line, so that, during Runs 7 and 8, the main concentrations of very fine sand were centered on the upper beach in the vicinity of the source lines. Runs 7 and 8 revealed a weak easterly drift of very fine sand. One week after emplacement, Run 9 revealed numerous isolated centers of high concentration, with the highest concentrations located west of the source lines, as shown on Plate 5-9. These concentration centers were more or less regularly spaced along the back of the beach. The last very fine marked grains were recovered on Run 10, two weeks after emplacement. These grains were found west of the source lines, some having moved as far as 2,700 feet.

Analysis of Marked Sand Movement

The longshore and onshore-offshore movements of the marked sand, shown in the plate series at the back of the thesis, are summarized graphically in Figure 6. Longshore drift, best illustrated by movement of the yellow marked sand from the across-beach source line, is shown in the upper half of the figure. Two bounding curves and a central curve are drawn for each grain-size range. The bounding curves represent the maximum east-west extent of the 50-grain contour surrounding the dominant

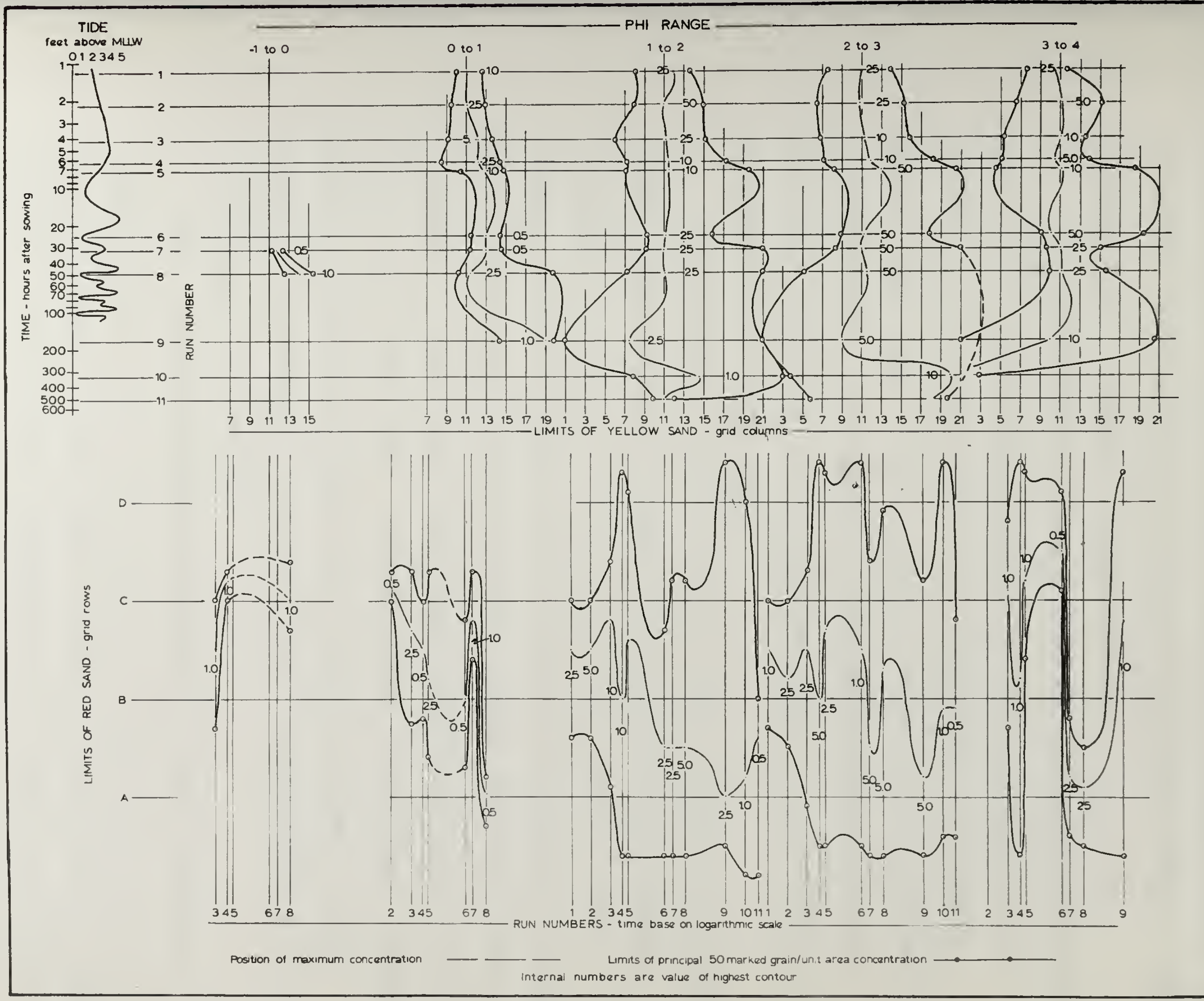


FIGURE 6
LIMITS OF MOVEMENT OF MARKED SAND

concentration center on the beach. The central curve represents the successive positions along the beach of the center of the dominant concentration.

Onshore-offshore transport, best revealed by movement of the red source line because of its orientation, is shown in the lower half of the figure in like manner, except that the onshore-offshore extent of the dominant concentration is referred to the grid rows (Figure 5). The tide curve for the first four days of the survey is also plotted in the figure.

Considering longshore drift first, Figure 6 reveals that coarse and very coarse grains experienced minimal lateral diffusion, as indicated by the smaller rate of spread of the 50 grain per unit area concentration lines. The trend of the coarse and very coarse sand was toward the east. Medium and fine grain concentrations oscillated about the source line, demonstrating no distinct littoral drift. Very fine marked grain movement showed a great deal of variability, but after Run 9 experienced a distinct westerly movement.

The onshore-offshore transport of the red marked sand indicates that the coarse and very coarse grains did not spread up and down the beach as much as the finer grains. Coarse grains migrated up the beach, and did not extend to seaward of the sampling grid. Medium, fine,

and very fine sand did extend to seaward of the grid. Medium and fine sand showed a definite tendency to move up the beach, as best indicated by the line of maximum concentration. Very fine sand was the most variable in its onshore-offshore movement.

6. RELATION OF MARKED SAND MOVEMENT TO ENVIRONMENTAL FACTORS

This section deals with the relation between marked sand movement and environmental factors. Each factor which might have been expected to contribute to marked sand transport or deposition -- cusps, profile changes, and natural beach texture -- is treated in turn. The daily wind and wave observations presented in Appendix E will not be discussed in detail as it is considered that the change in sand elevation measured at Profile B represents the integrated effects of wind and waves.

Cusp Occurrence

Cusps were present on the upper beach in the vicinity of the yellow source line throughout the survey, except on March 3, when none were noted. The mean position of the cusps for the three-week period is shown in Figure 7. The cusps remained very uniform in size and location, their lengths and apex positions not differing by more than about ten feet from the means indicated in the figure.

In the first few hours after emplacement, the red marked sand migrated more slowly up the beach in the cusp bays than on the cusp apexes. This relative movement is illustrated by the red marked sand pattern shown in Plates 3-1, 3-2, 4-1, and 4-2.

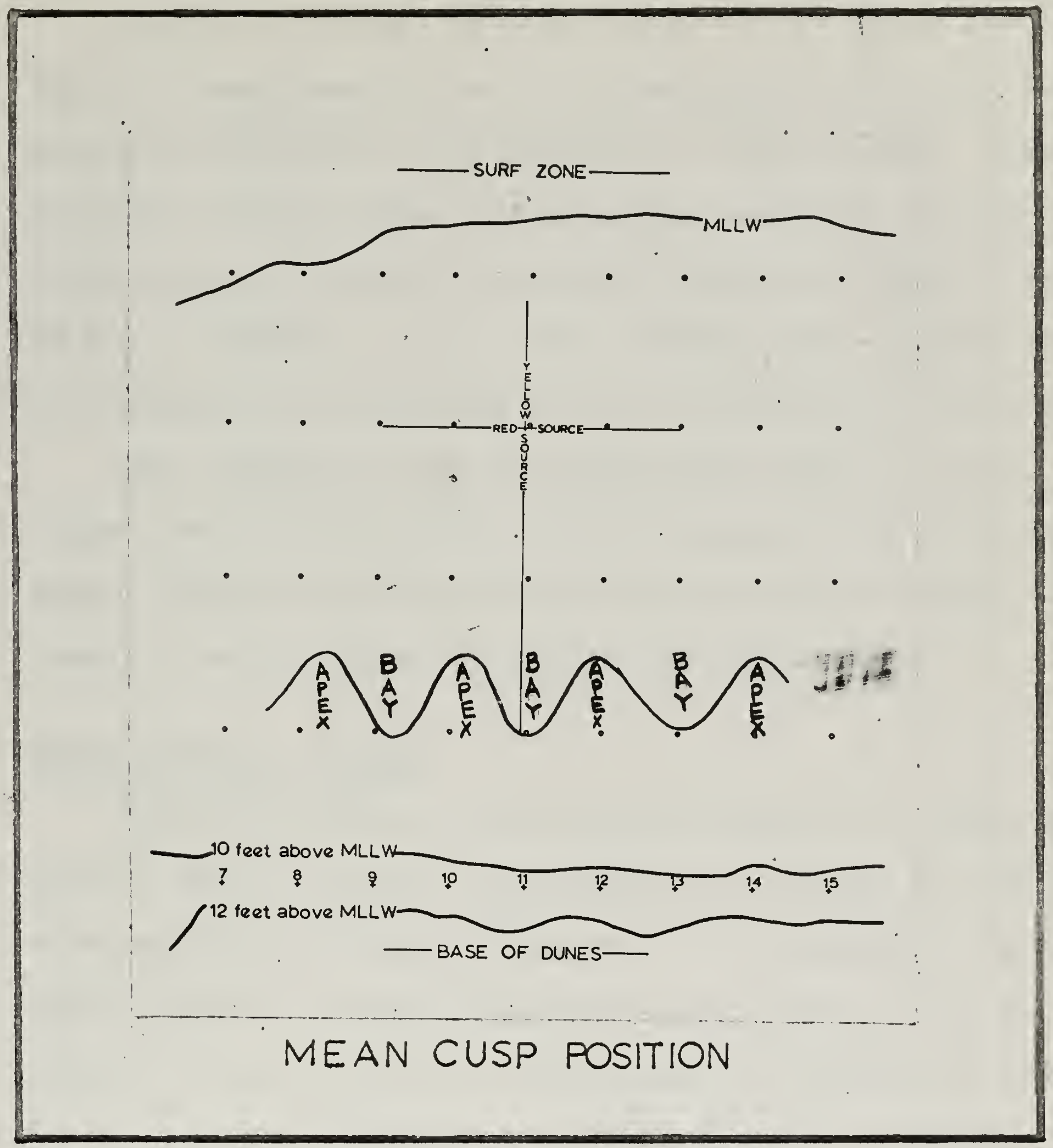


FIGURE 7
CUSP POSITIONS

After the marked sand had been on the beach for two days, it was found in well-defined cyclic concentrations which are believed to be related to cusp apexes. This apparent correspondence between the positions of cusp apexes and the periodic concentrations was found as early as Run 1 (Plates 3-1 and 3-2), but was most obvious in the patchy concentrations of Run 9 (Plates 4-9 and 5-9).

The concentrations of marked sand found on cusp apexes were predominantly in the fine and very fine grain sizes. Medium and coarse grain concentrations were not found to correlate as well with cusp occurrence.

Beach Profile Changes

Onshore-offshore sand movement during the three-week period, which reflects the integrated effects of changing wave conditions during the survey, is represented by the beach profile changes illustrated in Figures 8 and 9. Figure 8 shows the time variability of the profile between Rows A and D as measured at selected rails of Profile B. Figure 9 shows the beach profile for the dates of: (1) seeding, (2) most severe erosion, (3) Run 9, and (4) Run 11.

On all parts of the beach, there was an overall accretion of sand during the three-week survey. The maximum variation in sand level occurred at the elevation of Row C and amounted to 55 centimeters during the survey.

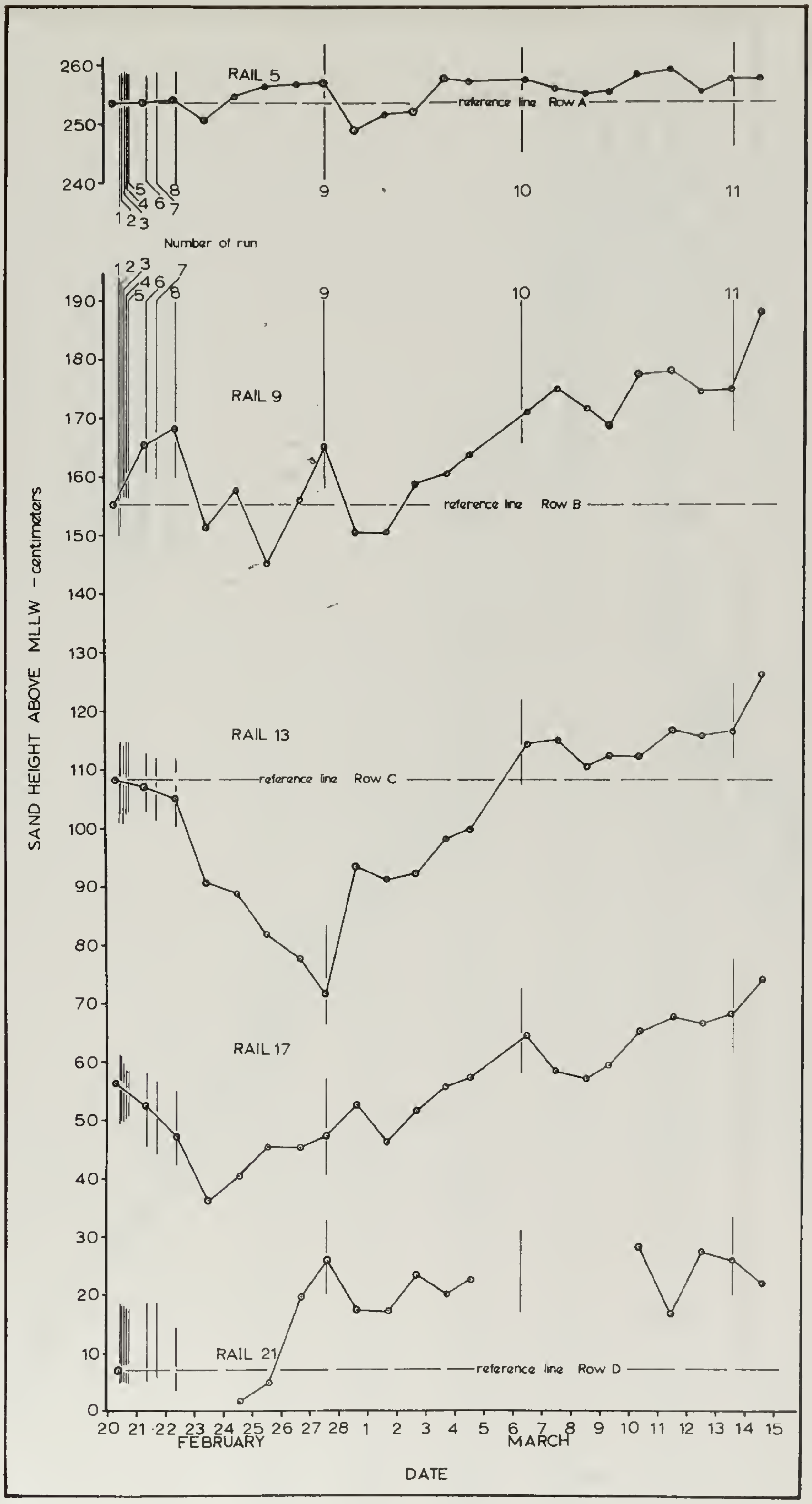


FIGURE 8
DAILY SAND ELEVATIONS AT
SELECTED RAILS OF PROFILE B

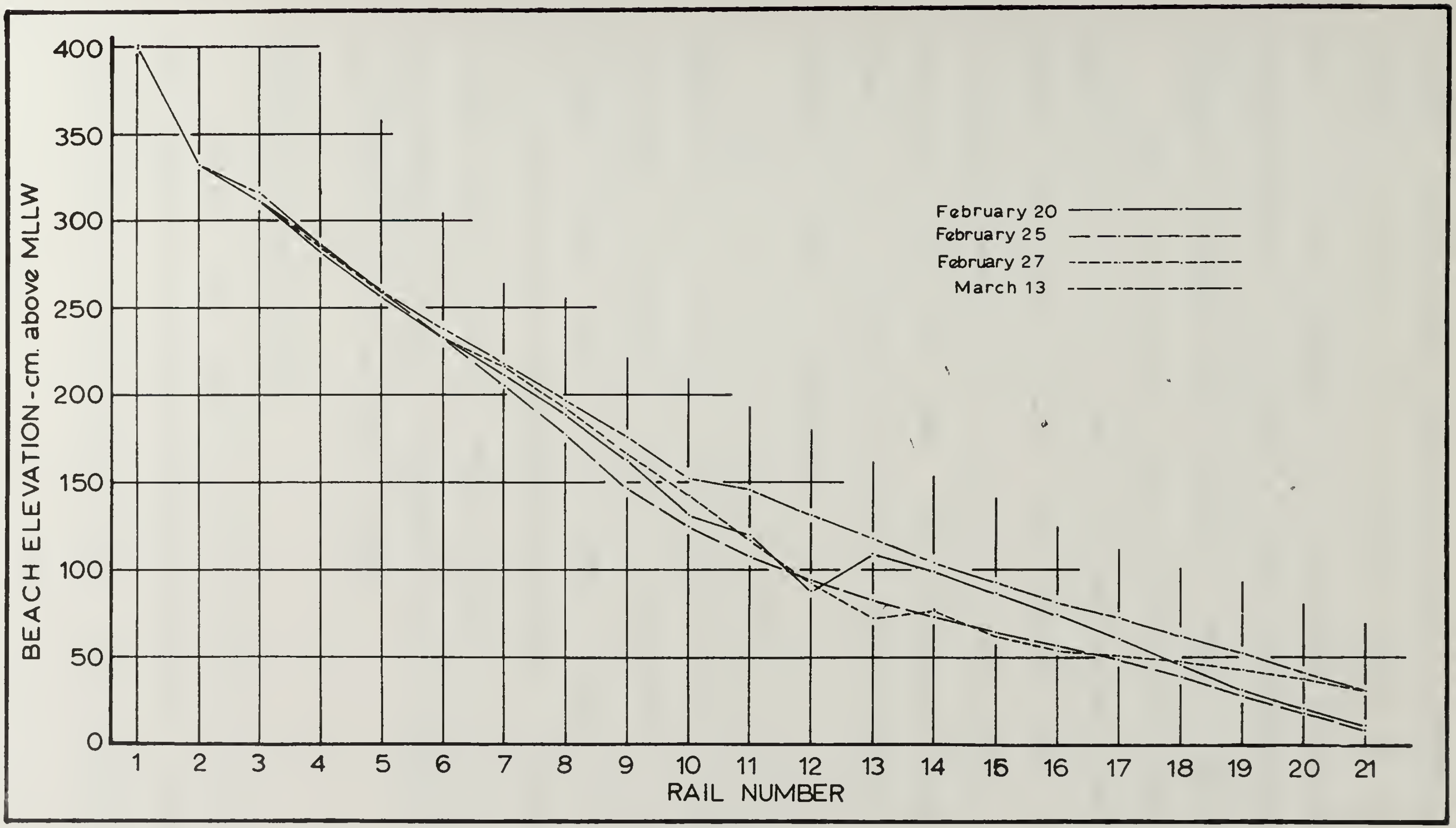


FIGURE 9

BEACH ELEVATIONS AT PROFILE B
ON SELECTED DAYS

It was observed that the beach profile underwent similar changes laterally over the entire length of the sample grid. For this reason, it is presumed that sand-elevation changes measured at Profile B are representative of the changes along the whole length of beach studied.

The yellow source line at Row B was covered by 12 centimeters of sand within two days after seeding (Run 8). Erosion occurred at Rows C and D on the lower beach, and completely removed this portion of the yellow source line after the first few runs. The red source line, along Row C, was completely removed by erosion within 24 hours after the time of seeding.

The low concentrations of marked sand found on Runs 10 and 11 may have been due to burial, presumably by onshore transport of sand. The absence of any significant littoral drift on the beach, along with the rise in sand level and the general movement of marked sand toward the rear of the beach, leads to the conclusion that onshore-offshore transport is the principal form of sand movement on Del Monte Beach.

Natural Beach Texture

It has been reported that the size of the natural sand grains on Del Monte Beach decreases from east to west (Koehr and Rohrbough, 1964). This observation is

confirmed for the small area of the initial grid by the textural analyses made on the background samples, the results of which are presented in Appendix A.

Sand samples collected along Profile B on February 20, 21, 22, and 27 and March 6 and 13 were also subjected to textural analysis. The results of these analyses, contained in Appendix D, showed that the sand at the back of the beach became progressively finer; at the seaward edge of the beach, coarser.

The movement of fine and very fine grains of marked sand toward the back of the beach during periods of accretion reflects the movement of the natural sand (Plates 4-8, 4-9, 4-10, 5-8, 5-9, and 5-10). It is observed that the motion of the emplaced sand was toward reestablishment of the natural alongshore gradient of sand diameter.

7. CONCLUSIONS

The determination of textural properties of sand samples by dry-volume percentages was found to produce results comparable to the standard weight-percentage method. In cases where many large samples must be processed, dry-volume measurements lead to a significant saving in time with no loss of accuracy.

During the three-week period of this study, the marked sand moved extensively back and forth across the beach face. However, it showed a definite tendency to move toward areas where the natural sand is the size of the marked grains. Very fine marked grains tended to move west; coarse and very coarse marked grains moved east. Fine and medium marked grains, of the same size as the natural grains, simply diffused from the source lines. This is interpreted as indicating that Del Monte Beach maintains its natural alongshore grain-size gradient by differential longshore transport of various sand sizes.

By the end of the survey, the sand elevation on the beach was generally higher than at any earlier time. In attempting to determine whether the marked sand might be buried by the indicated accretion of natural sand, a

trench was excavated and the sand profile examined for a layer of marked grains. No layer was found; rather, marked grains were distributed throughout the sand column. This indicated a mixing of _in situ_ sand with that carried onshore by wave action.

The profile of Del Monte Beach, in general, first eroded, then experienced accretion. On the first few sampling days, during the period of erosion on the middle and lower beach, sand was found spread across the beach face. Later, in the accretion period, the finer sizes of marked sand were found predominantly at the back of the beach. Additionally, the natural sand at the low-tide level became coarser with time; that at the back of the beach, finer. It is concluded that, during periods of erosion, some sand from throughout the eroded column remains on the beach face. Further, during periods of accretion, the fine and very fine sand is winnowed from the lower beach and deposited at the back of the beach.

In the first eight hours of this study, there was a distinct flow of red marked grains toward the upper beach along the apexes of the cusps immediately adjacent to Profile B. Later, high concentrations of marked sand were found on the cusp apexes. Future studies should consider sample spacing and intervals small enough to adequately study sand circulation within a single cusp domain.

8. ACKNOWLEDGMENTS

We extend our appreciation to our advisor, Professor Warren C. Thompson, Department of Meteorology and Oceanography, United States Naval Postgraduate School, for his assistance throughout the period of this study. We wish to acknowledge the use of laboratory equipment and other aid provided by the Office of Naval Research Foundation Grant to Professor Thompson. The authors are also indebted to the Del Monte Properties Company and Pacific Cement and Aggregates, Incorporated, for their donation of graded sand, and to Mr. Louis Burns, Pacific Cement and Aggregates, Incorporated for blending the various grades of sand to meet our specifications. Additionally, thanks are due to Mrs. David Jones who rendered assistance in typing and proofreading the manuscript.

BIBLIOGRAPHY

Brennan, J. F., and R. P. Meaux, 1964. Observations of The Nearshore Water Circulation off a Sand Beach. M. S. Thesis, U. S. Naval Postgraduate School, Monterey, California.

Ingle, J. C., 1962. "Tracing Beach Sand Movement By Means of Fluorescent Dyed Sand." Shore and Beach, October.

Inman, D. L., 1952. "Measures for Describing The Size Distributions of Sediments," Journal Sediment Petrology, v. 22, no. 3.

Koehr, J. E., and J. D. Rohrbough, 1964. Daily and Quasi-Weekly Beach Profile Changes at Monterey, California. M. S. Thesis, U. S. Naval Postgraduate School, Monterey, California.

Wright, F. F., 1962. The Development and Application of a Fluorescent Marking Technique for Tracing Sand Movement on Beaches. Columbia University, Department of Geology, Technical Report No. 2.

Yasso, W. E., 1962. Fluorescent Coatings on Coarse Sediments: An Integrated System. Columbia University, Department of Geology, Technical Report No. 1.

Yasso, W. E., 1964. Plan Geometry of Headland-Bay Beaches. Columbia University, Department of Geology, Technical Report No. 7.

APPENDIX A

MEDIAN DIAMETERS AND SORTING COEFFICIENTS

OF BACKGROUND SAMPLES

APPENDIX A

MEDIAN DIAMETERS AND SORTING COEFFICIENTS OF BACKGROUND SAMPLES

Sample Number[a]	Median Diameter (Φ)	Sorting Coefficient[b] (S_o)
1	2.08	0.31
2	2.20	0.34
3	2.16	0.36
4	2.04	0.30
5	2.17	0.35
6	2.12	0.33
7	2.19	0.33
8	2.25	0.32
9	2.20	0.32
10	2.14	0.33
11	2.15	0.35
12	2.20	0.33
13	2.11	0.34
14	2.03	0.38
15	2.07	0.38
16	1.93	0.36
17	2.03	0.36
18	1.91	0.30
19	1.92	0.38
20	1.98	0.38
21	2.19	0.36

[a]Background samples were drawn from the level of Rail 10 of Profile B, at the grid column designated by the sample number. See Figures 3 and 5.

[b]Calculated according to $S_o=\frac{1}{2}(\Phi_{84}-\Phi_{16})$ (Inman, 1952)

[illegible]

[illegible]

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

APPENDIX B

DATA FROM SAMPLE PROCESSING

APPENDIX B. – DATA FROM SAMPLE PROCESSING

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
1	8	B	481	9.0	0	0	0	0	0	0	0	0	0	0
1	8	C	575	8.7	0	0	0	0	0	0	0	1	0	1
1	8	D	490	9.7	0	0	0	0	0	0	0	0	0	0
1	9	B	485	8.3	0	0	0	0	1	1	1	0	0	1
1	9	C	569	8.7	0	0	0	0	0	2	0	2	0	0
1	9	D	555	9.0	0	0	0	0	0	1	0	0	0	2
1	10	B	490	9.9	0	0	0	0	1	12	1	6	0	2
1	10	C	400	9.9	0	0	0	1	0	2	0	1	0	0
1	10	D	457	10.6	0	0	0	1	0	3	0	8	0	6
1	11	B	450	10.0	0	0	0	1	0	39	0	39	0	4
1	11	C	495	9.1	0	0	0	2	0	2	0	0	0	0
1	11	D	480	9.7	0	0	0	0	0	7	0	5	0	0
1	12	B	425	9.2	0	0	0	0	0	3	0	12	0	0
1	12	C	450	9.2	0	0	0	2	0	58	0	8	0	0
1	12	D	580	9.7	0	0	0	0	0	0	0	4	0	0
1	13	B	489	18.2	0	0	0	0	11	4	4	6	0	0
1	13	C	395	20.0	0	0	0	0	0	0	0	0	0	0
1	13	D	300	13.5	0	0	0	0	0	0	0	0	0	0
1	14	B	667	22.1	0	0	0	0	0	0	0	0	0	0
1	14	C	519	18.0	0	0	0	0	0	0	0	0	0	0
1	14	D	317	17.1	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
2	7	B	392	8.0	0	0	0	0	0	0	0	3	0	2
2	7	C	447	7.3	0	0	0	0	0	0	0	1	0	0
2	7	D	384	9.0	0	0	0	0	0	0	0	1	0	2
2	8	B	265	7.2	0	0	0	0	0	0	0	2	0	2
2	8	C	470	8.4	0	0	0	0	0	0	0	0	0	0
2	8	D	465	8.0	0	0	0	0	0	0	0	1	0	3
2	9	B	501	9.0	0	0	0	0	4	11	2	25	0	2
2	9	C	453	29.5	0	0	0	0	1	1	0	4	0	1
2	9	D	337	7.9	0	0	0	0	0	2	0	12	0	7
2	10	B	467	9.2	0	0	0	1	4	20	1	55	0	12
2	10	C	575	13.1	0	0	0	1	0	4	0	3	0	2
2	10	D	447	6.9	0	0	0	0	0	2	0	3	0	0
2	11	B	483	7.9	0	0	0	2	0	90	0	55	0	4
2	11	C	540	10.0	0	0	0	0	0	4	0	3	0	0
2	11	D	397	6.9	0	0	0	0	0	1	0	0	0	0
2	12	B	387	9.9	0	0	0	0	11	22	7	36	0	7
2	12	C	467	7.5	0	0	1	3	0	33	0	6	0	0
2	12	D	350	19.5	0	0	0	0	1	1	0	2	0	0
2	13	B	465	8.5	0	0	0	0	1	3	3	4	0	1
2	13	C	540	6.4	0	0	0	0	0	1	0	0	0	0
2	13	D	455	8.9	0	0	0	0	0	0	0	3	0	5
2	14	B	420	8.0	0	0	0	0	0	4	0	0	0	0
2	14	C	325	6.3	0	0	0	0	0	1	0	1	0	0
2	14	D	417	7.5	0	0	0	0	0	0	0	0	0	0
2	15	B	430	8.9	0	0	0	0	0	1	0	1	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
2	15	C	535	8.0	0	0	0	0	0	0	0	0	0	0
2	15	D	392	7.0	0	0	0	0	0	0	0	0	0	0
3	6	B	465	11.0	0	0	0	0	0	0	0	0	0	2
3	6	C	310	13.0	0	0	0	0	20	0	0	1	0	1
3	6	D	240	14.5	0	0	0	0	0	0	0	3	0	10
3	7	B	398	12.1	0	0	0	0	2	4	1	5	0	3
3	7	C	433	12.3	0	0	0	0	0	0	0	1	0	1
3	7	D	341	10.9	0	0	0	0	0	1	0	1	0	6
3	8	A	309	11.6	0	0	0	0	0	0	0	0	0	0
3	8	B	419	10.5	0	0	0	0	0	4	0	3	0	3
3	8	C	420	13.7	0	0	0	0	0	0	0	2	0	5
3	9	A	347	12.1	0	0	0	0	0	0	0	2	0	0
3	9	B	392	10.5	0	0	0	0	2	8	4	10	0	2
3	9	D	524	11.5	0	0	1	0	0	0	0	4	0	1
3	10	A	277	14.2	0	0	0	0	1	1	0	3	0	0
3	10	B	437	10.3	0	0	0	2	4	37	0	19	0	0
3	10	C	494	14.4	0	0	0	1	6	23	1	40	9	46
3	11	A	206	12.3	0	0	0	0	0	7	3	19	0	8
3	11	B	386	16.5	1	1	6	25	50	158	11	24	0	5
3	11	C	435	16.5	0	0	0	4	2	30	5	55	0	9
3	12	A	271	13.0	0	0	0	0	0	2	0	0	0	0
3	12	B	478	10.9	0	0	0	0	26	37	5	33	3	7

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
3	12	C	543	15.0	1	1	10	16	16	71	2	24	0	12
3	13	A	357	13.0	0	0	0	0	0	2	1	0	0	0
3	13	B	475	10.3	2	0	3	2	13	1	2	0	0	1
3	13	C	389	15.5	0	0	0	0	3	5	7	6	0	5
3	14	A	366	12.3	0	0	0	0	0	2	0	0	0	0
3	14	B	447	14.4	0	0	1	0	2	4	3	2	1	1
3	14	C	488	18.3	0	0	2	0	1	0	0	0	0	1
3	14	D	54	15.0	0	0	0	0	1	1	0	3	0	1
3	15	A	294	12.5	0	0	0	0	0	0	0	0	0	0
3	15	B	479	11.2	0	0	0	0	0	0	0	0	0	0
3	15	C	545	10.0	0	1	0	0	0	0	0	2	0	0
3	15	D	60	12.3	0	0	0	1	0	0	0	2	0	0
3	16	A	361	12.7	0	0	0	0	0	0	0	0	0	0
3	16	B	418	11.8	0	0	0	0	0	0	0	0	0	0
3	16	C	468	13.3	0	0	0	0	0	0	0	0	0	0
3	16	D	147	17.9	0	0	0	0	0	0	0	0	0	0
4	6	B	443	15.0	0	0	0	0	0	0	0	0	0	0
4	6	C	386	22.7	0	0	0	0	0	0	0	0	0	2
4	6	D	434	12.6	0	0	0	0	0	0	0	0	0	4
4	7	B	239	17.6	0	0	0	0	0	0	0	1	0	2
4	7	C	262	11.0	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
4	7	D	320	12.2	0	0	0	0	0	0	0	1	0	1
4	8	A	276	16.4	0	0	0	0	0	0	0	3	0	2
4	8	B	340	17.6	0	0	0	0	3	6	1	5	2	4
4	8	C	446	13.4	0	0	0	0	0	0	0	3	0	0
4	8	D	370	14.8	0	0	0	0	1	1	0	6	2	20
4	9	A	285	19.0	0	0	0	0	0	0	0	1	0	1
4	9	B	392	14.4	0	0	0	2	8	7	0	3	2	1
4	9	C	389	18.1	0	0	2	2	2	1	0	3	0	0
4	9	D	261	15.4	0	0	0	0	0	3	3	6	2	8
4	10	A	246	16.5	0	0	0	0	0	0	0	0	0	1
4	10	B	397	17.5	1	1	0	0	81	25	25	18	1	6
4	10	C	387	21.1	0	0	0	3	10	28	6	31	4	7
4	10	D	318	16.5	0	0	0	0	2	13	4	18	6	29
4	11	A	230	14.0	0	0	0	0	4	11	3	18	9	2
4	11	B	308	15.5	0	1	1	3	46	77	20	37	0	2
4	11	C	351	20.2	1	0	1	3	22	45	32	52	11	8
4	12	A	271	13.5	0	0	0	0	9	13	5	14	0	2
4	12	B	307	17.6	0	0	3	8	44	72	8	17	0	3
4	12	C	449	14.5	4	0	0	7	19	38	12	30	0	11
4	13	A	312	16.7	0	0	0	0	55	22	25	10	0	1
4	13	B	436	14.4	0	0	2	6	51	49	17	16	0	2
4	13	C	435	16.5	0	0	0	0	3	3	1	8	1	4
4	14	A	362	19.0	0	0	0	0	13	5	31	12	3	0
4	14	B	372	9.0	0	0	0	2	21	22	3	5	1	0
4	14	C	560	11.7	0	0	1	0	2	1	1	0	2	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TC 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
4	15	A	385	9.5	0	0	0	0	6	7	2	0	2	2
4	15	B	413	8.5	0	0	2	0	12	1	1	3	0	0
4	15	C	280	7.2	0	0	0	0	1	1	1	2	0	0
4	16	A	342	10.8	0	0	0	0	1	1	6	1	0	0
4	16	B	398	9.1	0	0	0	0	4	2	2	2	0	1
4	16	C	250	10.4	0	0	0	0	0	0	10	1	5	10
4	16	D	475	16.5	0	0	0	0	0	0	C	2	2	6
4	17	A	405	7.7	0	0	0	0	1	1	0	2	0	1
4	17	B	330	10.0	0	0	0	1	8	1	3	1	0	1
4	17	C	254	8.5	0	C	0	0	0	2	2	2	1	3
4	18	A	455	8.2	0	0	0	0	0	0	0	1	0	0
4	18	B	575	9.7	0	C	0	0	0	0	0	1	0	0
4	18	C	350	9.8	0	C	0	0	0	0	C	0	0	0
5	1	B	346	13.4	0	0	0	0	0	0	C	0	0	1
5	1	C	281	10.8	0	0	0	0	0	0	C	0	0	0
5	1	D	359	11.4	0	0	0	0	0	0	0	0	0	2
5	2	B	354	9.5	0	0	0	0	2	0	0	0	0	0
5	2	C	241	13.2	0	0	0	0	0	0	0	0	1	0
5	2	D	397	9.8	0	0	0	0	1	0	1	0	0	0
5	3	B	295	13.3	0	0	0	0	0	1	0	1	0	0
5	3	C	297	17.1	0	0	0	0	0	0	C	0	0	1
5	3	D	325	13.7	0	0	0	0	0	0	C	0	0	0
5	4	B	298	9.8	0	0	0	0	0	0	C	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
5	4	C	284	11.7	0	0	0	0	1	0	C	0	0	0
5	4	D	265	10.6	0	0	0	0	0	0	0	0	0	0
5	5	B	398	12.0	0	0	0	0	0	0	0	0	0	1
5	5	C	321	9.3	0	0	0	0	0	0	0	1	0	0
5	5	D	318	10.8	0	0	0	0	0	0	0	0	0	2
5	6	B	377	9.9	0	0	0	0	0	1	0	0	0	0
5	6	C	293	10.0	0	0	0	0	0	0	0	0	0	0
5	6	D	450	10.9	0	0	0	0	0	0	0	3	0	6
5	7	B	360	10.3	0	0	0	0	0	0	0	1	0	1
5	7	C	364	11.9	0	0	0	0	0	0	0	0	0	0
5	7	D	342	12.6	0	0	0	0	1	0	0	1	0	3
5	8	A	451	13.0	0	0	0	0	0	0	0	1	0	0
5	8	B	386	8.4	0	0	0	0	0	2	0	1	0	1
5	8	C	348	11.5	0	0	0	0	0	0	C	1	0	4
5	9	A	310	19.8	0	0	0	0	0	0	0	0	0	0
5	9	B	324	12.5	0	0	0	0	0	4	2	3	0	0
5	9	C	321	16.1	1	0	0	0	0	2	0	2	1	4
5	9	D	640	11.8	0	0	0	0	0	1	0	5	0	13
5	10	A	340	10.0	0	0	0	0	0	1	0	0	0	0
5	10	B	365	8.6	0	0	1	0	11	5	1	6	0	0
5	10	C	397	10.7	0	0	0	1	3	21	0	12	0	2
5	10	D	460	11.1	0	0	0	0	2	5	0	8	0	2
5	11	A	269	9.1	0	0	0	0	3	7	3	8	0	2
5	11	B	352	5.7	0	0	0	0	0	13	1	10	0	3
5	11	C	378	9.5	0	0	0	5	7	44	2	20	0	3

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
5	11	D	428	11.0	0	0	0	0	0	9	4	30	0	37
5	12	A	255	8.4	0	0	0	0	1	0	1	2	0	2
5	12	B	342	10.0	0	0	0	2	14	42	1	13	0	0
5	12	C	335	11.8	0	1	6	1	5	13	6	16	1	0
5	12	D	464	10.2	0	0	0	0	1	4	4	17	0	18
5	13	A	376	11.6	0	0	0	0	17	11	15	12	1	4
5	13	B	445	14.5	0	0	4	6	28	30	12	23	0	0
5	13	C	481	17.0	1	0	3	1	11	15	6	24	2	2
5	13	D	393	14.6	0	0	0	0	0	0	3	4	5	11
5	14	A	350	18.2	0	0	0	0	25	10	18	6	0	1
5	14	B	400	11.7	1	0	3	3	16	19	3	8	0	0
5	14	C	500	12.5	0	0	0	0	0	1	1	7	0	0
5	14	D	451	17.2	0	0	0	0	0	0	0	1	0	2
5	15	A	235	8.5	0	0	0	0	6	1	2	2	0	0
5	15	B	375	12.3	0	0	9	1	18	21	3	7	0	0
5	15	C	483	15.4	0	0	0	0	5	3	14	21	4	9
5	15	D	331	9.4	0	0	0	0	0	0	0	0	1	1
5	16	A	278	11.0	0	0	0	0	1	3	3	5	0	0
5	16	B	205	10.0	0	0	0	0	5	3	0	4	0	0
5	16	C	390	9.4	0	0	0	0	2	2	8	5	2	7
5	16	D	230	11.0	0	0	0	0	0	0	0	0	0	3
5	17	A	231	11.7	0	0	0	0	0	0	0	0	0	0
5	17	B	394	11.0	0	0	0	0	5	7	3	1	1	0
5	17	C	307	12.1	0	0	0	0	0	1	0	2	0	1
5	18	A	366	9.0	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
5	18	B	258	11.0	0	0	0	0	2	0	0	1	0	0
5	18	C	418	10.7	0	0	0	0	0	1	1	2	0	2
5	19	A	358	14.5	0	0	0	0	2	2	0	2	0	0
5	19	B	369	13.2	0	0	0	0	2	0	2	3	1	1
5	19	C	490	10.5	0	0	0	0	0	0	3	4	0	0
5	20	A	340	8.8	0	0	0	0	0	0	0	0	0	0
5	20	B	465	9.8	0	0	0	0	0	0	0	0	1	1
5	20	C	409	8.7	0	0	0	0	0	1	0	2	0	1
5	21	A	300	10.0	0	0	0	0	0	0	0	0	0	0
5	21	B	295	14.6	0	0	0	0	0	0	0	0	0	0
5	21	C	273	15.0	0	0	0	0	0	1	1	1	0	1
6	1	A	310	7.0	0	0	0	0	0	1	1	1	0	0
6	1	B	366	7.5	0	0	0	0	0	2	0	2	0	0
6	1	C	243	9.5	0	0	0	0	0	1	0	2	1	0
6	1	D	377	6.8	0	0	0	0	0	0	0	0	0	0
6	2	A	238	13.0	0	0	0	0	0	0	0	0	0	0
6	2	B	371	12.6	0	0	0	0	0	0	0	0	0	0
6	2	C	310	11.8	0	0	0	0	0	0	0	0	0	0
6	3	A	251	6.8	0	0	0	0	0	0	0	0	0	0
6	3	B	376	6.9	0	0	0	0	0	0	0	1	0	0
6	3	C	345	8.9	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TC 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
6	3	D	376	7.0	0	0	0	0	C	0	0	0	0	0
6	5	A	206	7.6	0	0	0	0	0	0	0	0	0	0
6	5	B	240	6.8	0	0	0	0	0	0	C	0	0	0
6	5	C	345	7.7	0	0	0	0	0	0	0	1	0	0
6	5	D	436	7.4	0	0	0	0	0	1	0	0	0	0
6	7	A	197	7.0	0	0	0	0	0	0	C	0	0	1
6	7	B	291	8.9	0	0	0	0	0	0	0	0	0	0
6	7	C	324	8.3	0	0	0	0	0	1	0	0	0	0
6	7	D	299	7.3	0	C	0	0	0	0	0	0	0	1
6	9	A	238	7.7	0	0	0	0	1	0	0	2	0	0
6	9	B	250	7.8	0	0	0	0	C	0	0	0	0	0
6	9	C	265	11.2	0	0	0	0	0	0	0	2	0	0
6	9	D	358	12.7	0	0	0	0	0	0	C	0	0	0
6	10	A	209	11.2	0	0	0	0	0	0	2	2	0	0
6	10	B	202	15.3	0	0	0	0	0	2	1	1	0	2
6	10	C	266	13.2	0	0	0	0	0	3	C	2	0	0
6	10	D	314	11.2	0	0	0	0	0	3	0	11	0	21
6	11	A	246	11.6	0	0	0	1	9	188	6	426	0	0
6	11	B	266	11.9	0	0	0	0	2	12	C	13	0	10
6	11	C	180	13.4	0	0	0	2	1	5	C	3	0	7
6	11	D	446	11.7	0	0	0	0	0	5	C	5	0	2
6	12	A	235	15.2	0	0	1	2	31	46	1C	28	0	0
6	12	B	250	11.8	0	0	0	1	5	15	5	18	0	1
6	12	C	300	16.5	0	1	1	3	0	4	0	5	0	2
6	12	D	410	17.4	0	C	0	0	1	3	2	12	0	5

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
6	13	A	237	12.3	0	0	0	0	17	20	2	4	0	2
6	13	B	254	11.3	0	0	0	0	8	11	2	23	1	0
6	13	C	282	14.8	0	1	1	3	2	2	5	6	0	1
6	13	D	287	10.6	0	0	0	0	0	2	4	5	1	3
6	14	A	241	10.5	0	0	0	0	6	4	2	1	0	0
6	14	B	400	13.3	0	0	0	0	6	8	1	4	0	1
6	14	C	329	13.1	0	0	0	2	0	0	1	4	0	2
6	14	D	465	12.8	0	0	0	0	0	1	C	2	0	3
6	15	A	317	14.0	0	0	0	0	1	1	0	2	1	0
6	15	B	360	8.0	0	0	0	0	1	5	2	2	0	0
6	15	C	219	12.5	0	0	0	0	0	0	1	5	1	2
6	15	D	416	10.4	0	0	0	0	0	0	0	5	2	3
6	16	A	312	9.6	0	0	0	0	0	0	0	2	0	0
6	16	B	351	13.3	0	0	1	0	1	1	2	4	0	2
6	16	C	288	14.9	0	0	0	0	0	0	C	4	0	2
6	17	A	312	14.7	0	0	0	0	0	2	2	1	0	0
6	17	B	322	14.4	0	0	0	0	3	2	1	3	0	0
6	17	C	313	13.2	0	0	0	0	0	1	C	0	0	1
6	17	D	465	14.2	0	0	0	0	0	2	0	1	0	4
6	18	A	150	9.5	0	0	0	0	0	0	2	0	0	0
6	18	B	336	12.4	0	0	0	0	0	0	0	1	0	0
6	18	C	337	15.2	0	0	0	0	2	4	0	2	0	2
6	18	D	570	14.4	0	0	0	0	0	1	0	0	0	1
6	19	A	286	15.4	0	0	0	0	3	2	2	2	0	0
6	19	B	322	13.2	0	0	0	0	1	1	C	1	1	2

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
6	19	C	381	11.3	0	0	0	0	1	1	0	2	1	0
6	19	D	267	12.3	0	0	0	0	1	1	C	2	1	3
6	20	A	329	14.2	0	0	0	0	0	0	0	2	0	0
6	20	B	313	13.5	0	0	0	0	0	2	1	3	1	0
6	20	C	509	12.4	0	0	0	0	0	2	0	3	0	0
6	20	D	458	11.3	0	0	0	0	0	2	0	2	0	0
6	21	A	316	10.4	0	0	0	1	0	0	1	3	0	0
6	21	B	386	11.1	0	0	0	0	0	0	0	1	0	0
6	21	C	388	11.8	0	0	0	0	0	0	C	1	0	1
7	2	A	296	9.4	0	0	0	0	0	0	C	0	0	0
7	2	B	326	10.2	0	0	0	0	0	1	C	1	0	0
7	2	C	256	11.7	0	0	0	0	0	0	C	0	0	0
7	3	A	217	11.4	0	0	0	0	0	0	0	0	1	0
7	3	D	186	14.2	0	0	0	0	1	0	C	0	0	0
7	4	A	234	9.6	0	0	C	0	0	0	0	0	0	0
7	4	B	346	13.4	0	0	0	0	0	0	0	0	0	0
7	4	C	320	12.7	0	0	0	0	0	0	C	0	0	0
7	4	D	340	13.6	0	0	0	0	0	0	0	0	0	2
7	5	A	320	12.8	0	0	0	0	0	0	0	0	0	1
7	5	C	322	19.1	0	0	0	0	0	2	C	1	0	1
7	5	D	442	11.0	0	0	0	0	0	2	C	2	0	1
7	6	A	279	14.1	0	0	0	0	0	0	1	0	0	0
7	6	B	392	10.6	0	0	0	0	0	0	C	0	0	1
7	6	C	282	14.4	0	0	0	0	0	0	C	0	0	0

APPENDIX B. – DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
7	6	D	356	12.1	0	0	0	0	0	3	0	0	0	1
7	7	A	230	11.8	0	0	0	0	0	0	2	0	0	0
7	7	C	392	9.5	0	0	0	0	0	1	0	1	0	1
7	7	D	220	12.3	0	0	0	0	0	1	0	0	2	0
7	8	A	271	10.4	0	0	0	0	0	0	0	0	0	0
7	8	B	283	13.8	0	0	0	0	0	1	0	0	0	0
7	8	C	283	10.6	0	0	0	0	0	1	0	1	0	1
7	8	D	177	10.6	0	0	0	0	0	0	0	0	0	1
7	9	A	246	13.4	0	0	0	0	14	0	9	4	0	0
7	9	C	473	15.4	0	0	0	0	0	1	0	0	0	0
7	10	A	298	12.4	0	0	0	0	8	8	12	13	2	3
7	10	B	365	10.9	0	0	0	0	0	1	0	1	0	0
7	10	C	345	11.4	0	0	0	0	0	1	0	0	0	0
7	10	D	387	13.2	0	0	0	0	0	1	0	2	0	0
7	11	A	277	11.0	0	0	0	0	21	82	41	218	12	139
7	11	B	274	13.6	0	0	0	0	1	4	0	1	0	0
7	11	C	388	12.2	0	0	0	0	0	5	0	1	0	0
7	12	A	223	13.4	0	0	0	0	24	33	18	18	4	1
7	12	B	389	12.7	0	0	1	2	11	11	2	10	0	1
7	12	C	301	12.9	0	3	1	0	0	1	0	1	0	0
7	12	D	415	13.5	0	0	0	0	0	0	0	5	1	1
7	13	A	290	9.0	0	0	0	0	11	8	4	8	5	0
7	13	B	291	10.3	0	0	2	0	5	4	1	2	0	0
7	13	C	355	9.5	0	0	0	0	0	1	0	4	0	0
7	13	D	212	9.0	0	0	0	0	0	0	0	1	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
7	14	A	315	8.8	0	0	1	2	4	4	4	7	0	6
7	14	B	313	13.8	0	1	2	1	7	5	1	4	0	0
7	14	C	261	12.9	0	0	1	0	3	2	0	3	0	0
7	14	D	234	17.4	0	0	0	0	0	1	0	7	3	11
7	15	A	293	11.6	0	0	0	0	0	1	C	1	0	0
7	15	B	359	15.4	0	0	2	1	13	15	4	8	0	1
7	15	C	243	13.1	0	0	0	0	1	1	C	2	0	1
7	15	D	115	17.0	0	0	0	0	0	1	5	13	5	2
7	16	A	257	8.9	0	0	0	0	5	5	0	2	0	0
7	16	B	277	14.2	0	0	0	0	5	14	3	2	0	0
7	16	C	440	15.1	0	0	0	0	1	2	1	2	0	0
7	16	D	491	10.8	0	0	0	0	0	0	C	0	1	2
7	17	A	291	12.7	0	0	0	0	0	0	0	1	0	0
7	17	B	287	13.6	0	0	0	0	5	8	C	1	0	0
7	17	C	344	13.4	0	0	0	0	1	2	3	6	0	3
7	17	D	138	11.4	0	0	0	0	0	0	1	2	1	1
7	18	A	229	11.8	0	0	0	0	0	0	C	0	0	0
7	18	B	359	11.3	0	0	0	0	4	5	1	1	0	0
7	18	C	313	13.1	0	0	0	0	0	0	0	1	0	0
7	18	D	340	15.1	0	0	0	0	0	0	0	0	0	0
7	19	A	263	10.2	0	0	0	0	3	0	2	1	0	0
7	19	B	243	14.4	0	0	1	0	0	1	0	1	0	0
7	19	C	226	10.1	0	0	0	0	0	2	0	8	0	1
7	20	A	303	15.0	0	0	0	0	0	1	2	3	0	0
7	20	B	306	13.8	0	0	0	0	1	8	0	1	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

RUN	COL	ROW	VOLUMES (ML.) SAMPLE	VOLUMES (ML.) SPLIT	-1 TO 0 RED	-1 TO 0 YEL	0 TO 1 RED	0 TO 1 YEL	1 TO 2 RED	1 TO 2 YEL	2 TO 3 RED	2 TO 3 YEL	3 TO 4 RED	3 TO 4 YEL
7	20	C	248	13.3	0	0	0	0	0	2	3	6	1	2
7	20	D	217	11.3	0	0	0	0	0	0	0	4	2	2
7	21	A	117	13.9	0	0	0	0	0	2	1	1	0	0
7	21	B	240	12.9	0	0	0	0	1	4	1	3	0	0
7	21	C	386	10.1	0	0	0	1	3	1	5	6	0	0
7	21	D	237	13.8	0	0	0	0	0	0	0	2	0	2
7	22	A	249	10.1	0	0	0	0	0	2	0	2	0	0
7	22	B	292	13.0	0	0	0	0	0	4	1	1	0	0
7	22	C	369	12.4	0	0	0	0	1	3	6	5	0	1
7	22	D	200	12.8	0	0	0	0	0	2	2	4	1	1
8	1	A	358	12.4	0	0	0	0	0	0	0	1	0	1
8	1	B	493	12.9	0	0	0	0	0	0	0	0	0	0
8	1	C	517	12.3	0	0	1	0	0	0	0	0	0	0
8	1	D	469	14.5	0	0	0	0	0	0	0	0	0	0
8	2	A	393	10.3	0	0	0	0	0	0	0	0	0	1
8	2	C	612	9.1	0	0	0	0	0	0	0	0	0	0
8	2	D	520	11.0	0	0	0	0	0	0	0	0	0	0
8	3	A	335	13.0	0	0	0	0	0	0	0	0	0	0
8	3	B	553	15.5	0	0	0	0	0	0	0	0	0	0
8	3	C	612	15.4	0	0	0	0	0	0	0	0	0	1
8	3	D	518	14.7	0	0	0	0	4	7	4	3	0	1
8	4	A	427	11.6	0	0	0	0	0	0	0	0	0	1
8	4	C	545	9.4	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
8	4	D	558	12.0	0	0	0	0	0	0	0	0	0	0
8	5	A	441	9.2	0	0	0	0	0	0	0	0	1	0
8	5	B	516	14.8	0	0	0	0	0	0	0	0	0	0
8	5	C	588	14.7	0	0	0	0	0	0	0	0	0	0
8	5	D	460	12.9	0	0	0	0	0	1	0	1	0	0
8	6	A	394	8.8	0	0	0	0	0	0	0	3	0	2
8	6	B	535	10.0	0	0	0	0	0	0	0	0	0	0
8	7	A	432	14.6	0	0	0	0	4	0	0	1	0	2
8	7	B	516	13.5	0	0	0	0	0	0	0	0	0	0
8	7	C	590	13.1	0	0	0	0	0	0	0	0	0	0
8	7	D	503	14.8	0	0	0	0	0	0	0	0	0	0
8	8	A	490	12.1	0	0	0	0	0	2	0	5	0	1
8	8	B	510	10.0	0	0	0	0	1	5	1	7	0	2
8	9	A	451	7.4	0	0	0	0	2	1	5	5	1	0
8	9	B	562	11.9	0	0	0	0	0	0	0	0	0	0
8	9	C	583	10.3	0	0	0	0	0	0	0	0	0	0
8	9	D	555	12.7	0	0	0	0	0	0	0	1	0	1
8	10	A	404	13.0	0	0	0	0	1	5	6	5	5	2
8	10	B	493	8.8	0	0	0	0	1	0	0	1	0	0
8	10	C	566	11.2	0	0	0	0	0	0	0	0	0	0
8	10	D	540	8.2	0	0	0	0	0	2	0	1	0	0
8	11	A	458	12.1	0	0	0	7	10	67	14	197	1	114
8	11	B	612	11.6	0	0	0	0	2	3	4	2	0	0
8	11	C	530	12.5	0	0	0	1	2	3	0	3	0	0
8	11	D	527	12.1	0	0	0	0	0	0	0	1	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
8	12	A	497	9.5	0	0	0	1	18	34	12	18	0	5
8	12	B	535	9.6	0	0	0	0	1	8	0	4	0	0
8	12	C	609	11.6	0	0	0	0	0	2	2	5	0	0
8	12	D	564	9.4	0	0	0	0	0	1	0	0	0	0
8	13	A	450	12.6	0	0	0	1	16	27	7	27	0	3
8	13	B	520	11.5	0	0	0	0	7	26	0	6	0	0
8	13	C	555	14.7	4	2	1	5	0	4	1	5	0	1
8	13	D	510	10.9	0	0	0	0	3	0	0	1	0	0
8	14	A	450	13.8	0	0	0	0	7	27	14	23	0	1
8	14	B	523	11.6	0	0	0	2	4	16	0	10	0	0
8	14	C	486	12.5	0	0	0	1	0	3	0	0	0	1
8	14	D	479	10.2	0	0	0	0	0	1	1	3	0	0
8	15	A	459	9.9	0	0	0	0	6	18	6	18	0	1
8	15	B	448	11.5	0	0	0	0	6	14	3	11	0	0
8	15	C	565	9.7	0	2	2	3	2	2	2	5	0	1
8	15	D	515	10.1	0	0	0	0	0	0	0	0	0	1
8	16	A	504	12.9	0	0	0	0	6	24	2	18	1	0
8	16	B	647	11.3	0	0	0	2	3	9	3	4	0	0
8	16	C	532	14.9	0	0	0	2	0	7	0	2	0	0
8	16	D	619	12.9	0	0	0	0	0	1	0	1	0	0
8	17	A	471	11.5	0	0	0	0	7	11	1	6	0	0
8	17	B	550	13.0	0	0	0	2	11	17	2	10	1	0
8	17	C	550	13.4	0	1	1	1	2	2	0	4	0	1
8	17	D	470	13.6	0	0	0	0	0	1	0	1	1	0
8	18	A	497	9.8	0	0	0	0	4	17	3	14	0	4

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
8	18	B	556	15.9	0	0	0	0	4	8	0	8	0	1
8	18	C	538	13.1	1	0	1	4	1	5	0	0	0	0
8	18	D	493	17.6	0	0	0	0	0	0	0	0	0	0
8	19	A	411	9.4	0	0	0	0	0	5	1	3	2	0
8	19	B	581	14.2	0	0	0	1	5	7	2	7	1	1
8	19	C	500	11.0	0	1	2	3	4	7	3	6	0	0
8	19	D	380	12.1	0	0	0	1	0	1	0	1	0	0
8	20	A	480	15.8	0	0	0	0	2	5	0	1	0	1
8	20	B	544	13.9	0	0	0	0	2	4	0	6	0	1
8	20	C	509	15.3	0	0	0	0	0	1	0	7	0	0
8	20	D	413	12.2	0	0	0	0	0	0	0	3	0	0
8	21	A	435	12.6	0	0	0	0	0	0	0	2	0	0
8	21	B	509	11.8	0	0	0	0	4	2	12	0	1	0
8	21	C	594	14.3	0	0	0	0	1	2	2	8	0	5
8	21	D	456	12.7	0	0	0	0	0	0	0	5	0	2
9	1	A	483	28.3	0	0	0	0	1	3	0	4	0	3
9	1	B	523	13.6	0	0	0	0	0	0	0	0	0	0
9	1	C	543	14.4	0	0	0	0	0	0	1	0	2	1
9	1	D	586	12.3	0	0	0	0	0	0	0	0	6	1
9	2	A	511	9.6	0	0	0	0	2	0	10	12	20	8
9	2	B	492	14.9	0	0	0	0	0	0	0	0	0	0
9	2	C	523	16.7	0	0	0	0	0	0	0	0	0	0
9	2	D	494	11.4	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
9	3	A	548	10.9	1	0	1	0	0	8	8	20	13	16
9	3	B	621	10.1	0	0	0	0	0	0	1	0	0	0
9	3	C	524	14.7	0	0	0	0	0	0	0	3	0	0
9	3	D	543	9.1	0	0	0	0	0	0	0	0	0	0
9	4	A	541	12.3	0	0	0	0	1	2	4	4	9	3
9	4	B	480	11.9	0	0	0	0	0	0	0	1	0	0
9	4	C	487	14.2	0	0	0	0	0	1	0	2	0	0
9	4	D	653	14.4	0	0	0	0	0	0	1	1	0	0
9	5	A	511	12.6	0	0	0	0	0	0	0	0	0	0
9	5	B	615	11.3	0	0	0	0	0	0	0	3	0	1
9	5	C	555	12.4	0	0	0	0	0	0	0	2	0	0
9	5	D	603	14.7	0	0	0	1	0	0	0	0	0	0
9	6	A	555	8.4	0	0	1	0	4	5	6	7	7	3
9	6	B	615	13.4	0	0	0	0	0	0	0	1	0	0
9	6	C	525	12.1	0	0	0	0	0	2	1	2	13	2
9	6	D	524	12.0	0	0	0	0	0	0	0	1	0	0
9	7	A	486	10.4	0	0	0	0	0	0	0	0	0	0
9	7	B	532	11.0	0	0	0	0	0	0	0	0	0	0
9	7	C	550	12.9	0	0	0	0	0	0	1	3	0	1
9	7	D	571	13.8	0	0	0	0	0	4	0	3	0	0
9	8	A	532	11.8	0	0	0	0	0	1	0	0	0	0
9	8	B	473	12.4	0	0	0	0	0	2	0	1	0	0
9	8	C	519	13.8	0	0	0	0	0	1	0	1	0	0
9	8	D	572	14.8	0	0	0	0	0	2	0	0	0	0
9	9	A	535	9.2	0	0	0	0	2	4	7	8	7	5

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
9	9	B	532	13.2	0	0	0	0	0	1	0	1	0	0
9	9	C	469	12.7	0	0	0	0	0	0	0	0	0	0
9	9	D	511	12.7	0	0	0	0	0	3	0	1	0	0
9	10	A	545	14.4	0	0	0	0	0	2	1	1	0	0
9	10	B	505	10.8	0	0	0	0	1	3	1	2	0	0
9	10	C	662	12.5	0	0	0	0	0	0	0	5	0	0
9	10	D	552	10.4	0	0	0	0	0	3	2	2	0	30
9	11	A	493	14.7	0	0	0	0	0	3	1	1	0	0
9	11	B	459	13.8	0	0	0	0	0	0	0	1	0	0
9	11	C	639	13.2	0	0	0	0	0	2	0	1	0	0
9	11	D	434	9.5	0	0	1	0	2	3	0	0	0	0
9	12	A	500	9.1	0	0	0	0	0	5	0	6	0	0
9	12	B	383	11.1	0	0	0	0	1	2	0	0	1	0
9	12	C	510	13.9	0	0	0	0	0	4	0	2	1	0
9	12	D	578	10.9	0	0	0	0	1	3	0	1	1	0
9	13	A	553	9.1	0	0	0	0	0	0	1	2	0	0
9	13	B	376	11.6	0	0	0	0	0	1	1	1	0	0
9	13	C	622	12.6	0	0	0	0	1	0	0	1	0	0
9	13	D	561	10.5	0	0	0	0	1	4	0	2	0	0
9	14	A	530	11.5	0	0	0	0	0	0	0	5	1	0
9	14	C	526	8.9	0	0	0	0	1	3	0	1	0	0
9	14	D	490	14.9	0	0	0	0	0	7	0	5	0	0
9	15	A	542	9.2	1	0	0	0	2	4	4	7	3	2
9	15	B	481	13.9	0	0	0	2	0	1	0	1	0	0
9	15	C	649	12.0	0	0	0	0	0	4	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
9	15	D	572	11.6	0	0	0	0	0	5	0	1	0	0
9	16	A	627	9.4	0	0	0	0	2	3	11	3	5	0
9	16	B	495	27.2	0	0	0	C	0	4	1	4	0	0
9	16	C	638	14.1	0	1	0	0	0	6	C	0	0	0
9	16	D	465	11.5	0	0	0	0	0	3	0	5	0	0
9	17	A	517	9.1	0	0	0	0	0	0	C	1	0	0
9	17	B	483	9.8	0	0	0	0	0	5	C	0	0	0
9	17	C	691	12.7	0	0	0	1	0	1	0	2	1	0
9	17	D	453	12.3	0	0	0	1	3	3	C	0	2	0
9	18	A	495	14.1	0	0	0	0	2	3	4	5	2	1
9	18	B	678	12.0	0	0	0	0	1	0	2	3	2	0
9	18	C	675	11.0	0	0	0	0	0	0	C	3	0	0
9	18	D	470	16.7	0	0	0	2	0	1	C	2	0	0
9	19	A	510	10.7	0	0	0	0	0	1	C	0	0	0
9	19	B	653	10.8	0	0	0	2	0	1	C	0	0	0
9	19	C	589	9.0	0	0	0	0	0	0	C	3	0	0
9	19	D	482	12.6	0	0	0	0	0	0	0	1	0	0
9	20	A	460	13.7	0	0	0	0	1	4	C	0	1	0
9	20	B	542	9.2	0	0	0	0	0	1	C	2	2	0
9	20	C	543	13.4	0	0	0	0	0	5	2	4	3	2
9	20	D	524	12.0	0	0	0	0	0	1	0	2	2	0
9	21	A	540	9.3	0	0	0	0	0	4	1	5	0	0
9	21	B	617	22.1	0	0	0	0	1	4	C	1	0	0
9	21	C	578	25.4	0	0	0	0	2	3	1	4	2	0
9	21	D	430	20.9	0	0	0	0	0	1	C	6	2	0

[illegible]

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
10	2	A	485	14.1	0	0	0	0	0	0	0	0	0	0
10	2	B	550	8.7	0	0	0	0	0	0	0	0	0	0
10	2	C	542	13.7	0	0	0	0	0	0	0	0	0	0
10	4	A	540	16.8	0	0	0	0	0	0	0	0	0	0
10	4	B	496	13.7	0	0	0	0	0	0	0	0	0	0
10	4	C	524	13.8	0	0	0	0	0	0	0	0	0	0
10	5	A	510	11.0	0	0	0	0	0	0	0	0	0	0
10	5	B	572	9.2	0	0	0	0	1	0	0	0	0	0
10	5	C	510	10.3	0	0	0	0	0	0	0	0	0	0
10	6	A	530	16.9	0	0	0	0	0	0	0	0	0	0
10	6	B	556	13.3	0	0	0	0	0	2	0	0	0	0
10	6	C	433	12.7	0	0	0	0	0	0	0	0	0	0
10	7	A	542	9.2	0	0	0	0	0	0	0	1	0	0
10	7	B	395	10.0	0	0	0	0	0	0	0	0	0	0
10	7	C	530	12.5	0	0	0	0	0	0	0	1	0	0
10	8	A	486	18.2	0	0	0	0	0	2	0	0	0	0
10	8	B	480	10.9	0	0	0	0	0	1	0	1	0	0
10	8	C	487	15.0	0	0	0	0	0	0	0	0	0	1
10	9	A	512	11.2	0	0	0	0	1	2	0	1	0	0
10	9	B	332	9.9	0	0	0	0	0	0	0	0	0	0
10	9	C	450	14.2	0	0	0	0	0	1	0	0	1	0
10	10	A	549	13.2	0	0	0	0	0	1	1	1	0	0
10	10	B	351	15.3	0	0	0	0	0	1	1	4	0	0
10	10	C	513	13.9	0	0	0	0	0	0	0	1	1	0
10	11	A	520	9.6	0	0	0	0	0	1	0	1	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
10	11	B	380	12.1	0	0	0	0	0	1	0	1	0	0
10	11	C	470	9.6	0	0	0	0	0	0	0	1	0	0
10	12	A	534	12.6	0	0	0	0	2	3	0	1	0	0
10	12	B	329	14.7	0	0	0	0	0	0	0	1	0	0
10	12	C	484	13.1	0	0	0	0	0	0	0	2	0	0
10	13	A	582	10.3	0	0	0	0	0	1	0	0	0	0
10	13	B	425	12.2	0	0	0	0	0	0	0	1	0	0
10	13	C	458	11.9	0	0	0	0	0	0	0	0	0	0
10	14	A	490	11.5	0	0	0	0	0	0	0	0	0	0
10	14	B	475	8.7	0	0	0	0	0	1	1	0	0	0
10	14	C	460	12.3	0	0	0	0	0	0	0	0	0	0
10	15	A	521	9.8	0	0	0	0	0	0	0	0	0	0
10	15	B	540	9.2	0	0	0	0	0	0	0	1	0	0
10	15	C	612	12.3	0	0	0	0	0	0	0	1	0	0
10	16	A	441	20.1	0	0	0	0	0	1	0	0	0	0
10	16	B	648	17.0	0	0	0	0	0	0	0	0	0	0
10	16	C	536	10.1	0	0	0	0	0	0	0	0	0	1
10	17	A	582	8.5	0	0	0	0	0	0	0	0	0	0
10	17	B	672	11.2	0	0	0	0	0	0	0	0	0	0
10	18	A	555	8.3	0	0	0	0	1	0	0	0	1	0
10	18	B	611	15.7	0	0	0	0	0	0	0	0	0	0
10	18	C	496	18.9	0	0	0	0	0	0	0	0	0	0
10	19	A	520	13.9	0	0	0	0	0	0	0	0	0	0
10	19	B	571	8.2	0	0	0	0	0	0	0	0	0	0
10	19	C	446	14.1	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
10	20	A	504	9.0	0	0	0	0	0	0	0	0	0	0
10	20	B	648	13.4	0	0	0	0	0	0	0	0	0	0
10	20	C	458	9.0	0	0	0	0	0	0	0	0	1	0
10	21	A	457	14.4	0	0	0	0	0	0	0	0	0	0
10	21	B	435	10.6	0	0	0	0	0	0	0	0	0	0
10	21	C	483	10.8	0	0	0	0	0	0	0	0	0	0
10	22	A	487	11.8	0	0	0	0	0	0	0	0	0	0
10	22	B	722	15.6	0	0	0	0	0	1	0	0	0	0
10	22	C	570	17.2	0	0	0	0	0	1	0	0	0	0
10	23	B	637	10.6	0	0	0	0	0	0	0	0	0	0
10	23	C	512	6.6	0	0	0	0	0	0	0	0	0	0
10	24	A	524	11.4	0	0	0	0	0	0	0	0	0	0
10	24	B	487	14.5	0	0	0	0	0	0	0	0	0	0
10	25	A	555	9.4	0	0	0	0	0	0	0	0	0	0
10	25	B	558	12.0	0	0	0	0	0	0	0	0	0	0
10	26	A	548	7.3	0	0	0	0	1	0	0	0	0	0
10	26	B	492	9.2	0	0	0	0	0	0	0	0	0	0
10	27	A	546	14.6	0	0	0	0	0	0	0	0	0	0
10	27	B	490	12.2	0	0	0	0	0	0	0	0	0	0
10	28	A	575	12.9	0	0	0	0	0	0	0	0	0	0
10	28	B	520	10.2	0	0	0	0	0	0	0	0	1	0
10	29	A	580	11.0	0	0	0	0	0	0	0	0	0	0
10	29	B	602	14.8	0	0	0	0	0	0	0	0	0	0
10	30	A	603	7.0	0	0	0	0	0	0	0	0	0	0
10	30	B	575	12.3	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TC 4	
RUN	COL	RCW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
11	2	A	534	11.2	0	0	0	0	0	0	C	0	0	0
11	2	B	583	10.3	0	0	0	0	0	0	0	0	0	0
11	2	C	341	8.5	0	0	0	0	0	0	0	0	0	0
11	4	A	502	12.6	0	0	0	0	0	0	0	0	0	0
11	4	B	661	10.0	0	0	0	0	0	0	C	0	0	0
11	4	C	595	11.7	0	0	0	0	0	0	0	0	0	0
11	6	A	479	11.0	0	0	0	0	0	0	C	0	0	0
11	6	B	668	10.9	0	0	0	0	0	0	C	0	0	0
11	6	C	569	9.4	0	0	0	0	0	0	0	0	0	0
11	7	B	606	10.8	0	0	0	0	0	0	0	0	0	0
11	8	A	491	10.9	0	0	0	0	0	0	C	0	0	0
11	8	B	670	8.3	0	0	C	0	0	0	0	1	0	0
11	8	C	521	12.7	0	0	0	0	0	0	C	0	0	0
11	9	A	551	7.8	0	0	0	0	0	0	1	0	0	0
11	9	B	628	9.6	0	0	0	0	0	0	0	0	0	0
11	10	A	550	11.4	0	0	0	0	0	2	0	0	0	0
11	10	B	517	10.2	0	C	0	0	0	0	C	0	0	0
11	10	C	566	6.9	0	0	0	0	0	0	0	0	0	0
11	11	A	478	10.9	0	0	0	0	0	0	0	0	0	0
11	11	B	642	8.8	0	0	0	0	0	0	0	0	0	0
11	11	C	574	11.7	0	0	0	0	0	0	0	1	0	0
11	12	A	558	11.0	0	0	0	0	0	0	0	0	0	0
11	12	B	641	9.7	0	0	0	0	0	1	C	0	0	0
11	12	C	560	10.1	0	0	0	0	0	1	C	0	0	0
11	13	B	622	11.4	0	0	0	0	0	0	0	0	0	0

APPENDIX B. - DATA FROM SAMPLE PROCESSING (CONTINUED)

			VOLUMES (ML.)		NUMBERS OF MARKED GRAINS IN PHI RANGES									
					-1 TO 0		0 TO 1		1 TO 2		2 TO 3		3 TO 4	
RUN	COL	ROW	SAMPLE	SPLIT	RED	YEL	RED	YEL	RED	YEL	RED	YEL	RED	YEL
11	13	C	471	10.3	0	0	0	0	0	0	0	0	0	0
11	14	A	596	10.5	0	0	0	0	0	0	0	0	0	0
11	14	B	520	10.6	0	0	0	0	1	0	0	0	0	0
11	14	C	553	11.8	0	0	0	0	0	0	0	0	0	0
11	15	B	621	12.4	0	0	0	0	0	0	0	0	0	0
11	16	A	549	10.7	0	0	0	0	0	0	0	0	0	0
11	16	B	600	11.7	0	0	0	0	0	0	0	0	0	0
11	16	C	519	12.8	0	0	0	0	0	0	0	0	0	0
11	18	A	489	14.1	0	0	0	0	0	0	0	0	0	0
11	18	B	500	12.9	0	0	0	0	0	0	0	0	0	0
11	18	C	488	13.3	0	0	0	0	0	0	0	0	0	0
11	20	A	590	13.5	0	0	0	0	0	0	0	0	0	0
11	20	B	642	13.5	0	0	0	0	0	0	0	0	0	0
11	20	C	399	13.0	0	0	0	0	0	0	0	0	0	0
11	22	A	547	14.6	0	0	0	0	0	0	0	0	0	0
11	22	B	574	13.7	0	0	0	0	0	0	1	0	0	0
11	24	A	591	16.1	0	0	0	0	0	0	0	0	0	0
11	24	B	547	12.0	0	0	0	0	0	0	0	1	0	0
11	24	C	506	12.3	0	0	0	0	0	0	0	0	0	0
11	26	A	516	15.0	0	0	0	0	0	0	0	0	0	0
11	26	B	560	16.7	0	0	0	0	0	0	0	0	0	0
11	26	C	436	14.6	0	0	0	0	0	0	0	0	0	0

APPENDIX C

COMPARISON BETWEEN CUMULATIVE GRAIN-SIZE DISTRIBUTIONS BY WEIGHT PERCENT AND VOLUME PERCENT

APPENDIX C

COMPARISON BETWEEN CUMULATIVE GRAIN-SIZE DISTRIBUTIONS

BY WEIGHT PERCENT AND VOLUME PERCENT

Sample Number[a]	Φ	Weight (g.)	Volume (ml.)	Cumulative Percent Weight	Cumulative Percent Volume
1		0.0	0.0	0.00	0.00
	-1				
		0.0	0.0	0.00	0.00
	0				
		0.09	0.03	0.06	0.03
	1				
		58.67	36.2	38.15	37.61
	2				
		94.32	59.5	99.40	99.39
	3				
		0.86	0.57	99.55	99.98
	4				
		0.07	0.02	100.00	100.00
		154.01	96.32		
3		0.0	0.0	0.00	0.00
	-1				
		0.0	0.0	0.00	0.00
	0				
		0.12	0.05	0.06	0.04
	1				
		66.22	41.5	32.04	31.87
	2				
		139.50	88.0	99.43	99.37
	3				
		1.14	0.72	99.98	99.92
	4				
		0.05	0.04	100.00	99.95
		207.03	130.31		
5		0.0	0.0	0.00	0.00
	-1				
		0.0	0.0	0.00	0.00
	0				
		0.0	0.05	0.00	0.04
	1				
		57.89	35.6	31.67	31.58
	2				
		122.48	75.9	98.68	98.81
	3				
		2.33	1.29	99.96	99.96
	4				
		0.08	0.05	100.00	100.00
		182.78	112.89		

APPENDIX C (continued)

Sample Number	Φ	Weight (g.)	Volume (ml.)	Cumulative Percent Weight	Cumulative Percent Volume
17		0.0	0.0	0.00	0.00
	-1	0.0	0.0	0.00	0.00
	0	0.47	0.48	0.24	0.38
	1	91.75	59.2	47.35	47.38
	2	101.56	65.3	99.50	99.22
	3	0.77	0.59	99.89	99.69
	4	0.21	0.39	100.00	100.00
		194.76	125.96		
19		0.0	0.0	0.00	0.00
	-1	0.0	0.0	0.00	0.00
	0	0.91	0.59	0.52	0.52
	1	106.48	68.4	60.88	60.67
	2	68.47	44.1	99.70	99.45
	3	0.41	0.38	99.93	99.78
	4	0.21	0.25	100.00	100.00
		176.39	113.72		
21		0.0	0.0	0.00	0.00
	-1	0.0	0.0	0.00	0.00
	0	0.52	0.05	0.31	0.52
	1	84.01	35.6	50.39	50.22
	2	82.82	75.9	99.76	99.65
	3	0.29	1.29	99.93	99.86
	4	0.12	0.05	100.00	100.00
		167.76	109.25		
1-11-B		0.0	0.0	0.00	0.00
	-1	0.07	0.10	0.05	0.10
	0	2.89	2.09	1.98	2.28
	1	75.32	47.5	52.37	51.77
	2	70.66	45.4	99.65	99.06
	3	0.51	0.63	99.99	99.72
	4	0.02	0.27	100.00	100.00
		149.47	95.99		

APPENDIX C (continued)

Sample Number	Φ	Weight (g.)	Volume (ml.)	Cumulative Percent Weight	Cumulative Percent Volume
1-11-C		0.21	0.2	0.15	0.22
	-1	4.20	2.63	3.08	3.11
	0	5.81	4.00	7.14	7.50
	1	67.15	42.3	54.06	53.92
	2	65.16	41.15	99.59	99.09
	3	0.53	0.53	99.96	99.67
	4	0.06	0.3	100.00	100.00
		143.12	91.11		
1-11-D		1.76	1.33	0.93	1.10
	-1	5.64	3.57	3.89	4.04
	0	13.83	8.78	11.16	11.28
	1	107.94	67.9	67.91	67.29
	2	60.62	39.0	99.78	99.46
	3	0.39	0.48	99.99	99.85
	4	0.02	0.18	100.00	100.00
		190.20	121.24		

[a]Samples designated by one number were drawn from the corresponding column of the initial grid (Figure 5) at the level of Rail 10 of Profile B (Figure 3). Other sample numbers are given as Run-Column-Row, as determined by the initial grid.

APPENDIX D

MEDIAN DIAMETERS AND SORTING COEFFICIENTS OF SAMPLES COLLECTED AT PROFILE B ON SAMPLING DAYS

APPENDIX D

MEDIAN DIAMETERS AND SORTING COEFFICIENTS OF SAMPLES COLLECTED AT PROFILE B ON SAMPLING DAYS

Sample Number[a]	Median Diameter (Φ)	Sorting Coefficient[b] (S_o)
1-11-B	1.98	0.44
1-11-C	2.00	0.38
1-11-D	1.91	0.47
6-11-A	2.09	0.30
6-11-B	2.00	0.25
6-11-C	1.78	0.64
6-11-D	1.88	0.40
8-11-A	2.05	0.38
8-11-B	1.92	0.44
8-11-C	1.96	0.44
8-11-D	1.84	0.50
9-11-A	2.20	0.34
9-11-B	2.07	0.34
9-11-C	1.96	0.38
9-11-D	1.87	0.39
10-13-A	2.03	0.38
10-13-B	1.60	0.64
10-13-C	1.63	1.19[c]
11-10-A	2.08	0.30
11-10-B	2.08	0.32
11-10-C	2.04	0.41

[a]Samples are designated Run-Column-Row as designated by the grid appropriate to the run number.

[b]Calculated according to $S_o = \frac{1}{2}(\Phi_{84} - \Phi_{16})$ (Inman, 1952).

[c]Sample drawn from rip channel.

APPENDIX E

DAILY WIND AND WAVE OBSERVATIONS ON DEL MONTE BEACH

APPENDIX E

DAILY WIND AND WAVE OBSERVATIONS ON DEL MONTE BEACH

Date	Wind Direction	Wind Speed (kts.)	Wave Height (ft.)	Wave Period (sec.)
20 Feb	calm		0.3-0.8	14
21 Feb	var	3-6	0.8-1.0	7
22 Feb	NW	3-8	1.0-1.5	6
23 Feb	NW	3-6	1.0	15
24 Feb	N	3-5	0.5-1.5	13
25 Feb	N	5	1.0	20
26 Feb	NW	2	0.3-0.5	12
27 Feb	WNW	16	1.0-1.5	6
28 Feb	WNW	12	2.5	10
1 March	NNW	6	1.0-1.5	10
2 March	W	2-4	1.0	10
3 March	NW	3-5	1.0	16
4 March	S	2-4	0.3	14
6 March	calm		0.5	11
7 March	calm		0.5	11
8 March	calm		3.0	12
9 March	NNW	3-5	1.5	15
10 March	SW	1-3	2.0	17
11 March	NW	7-10	0.8	14
12 March	W	5-8	1.5	9
13 March	WNW	4-8	0.5	12

PLATES

MARKED SAND DISTRIBUTION

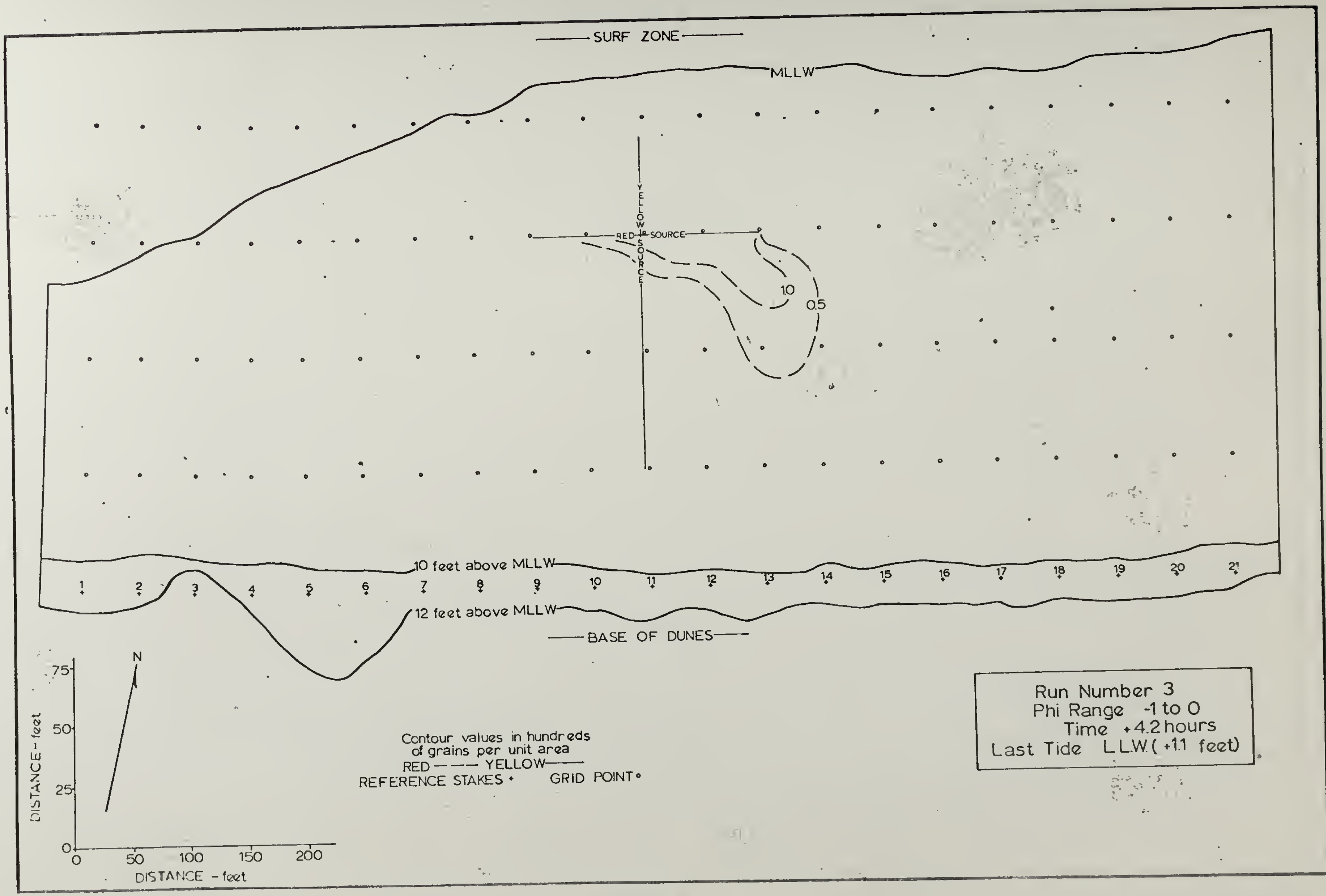


PLATE 1-1

MARKED SAND DISTRIBUTION

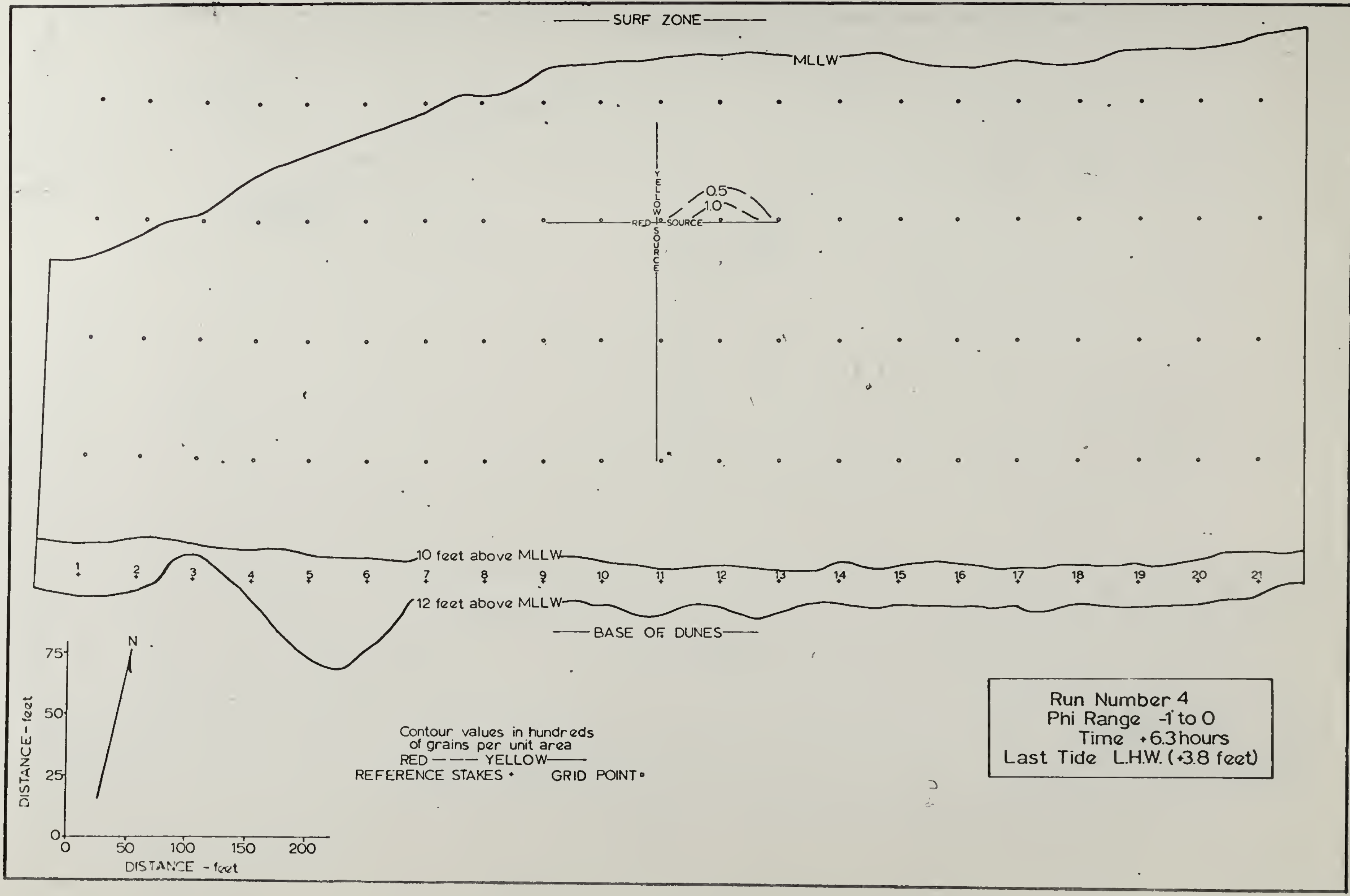


PLATE 1-2

MARKED SAND DISTRIBUTION

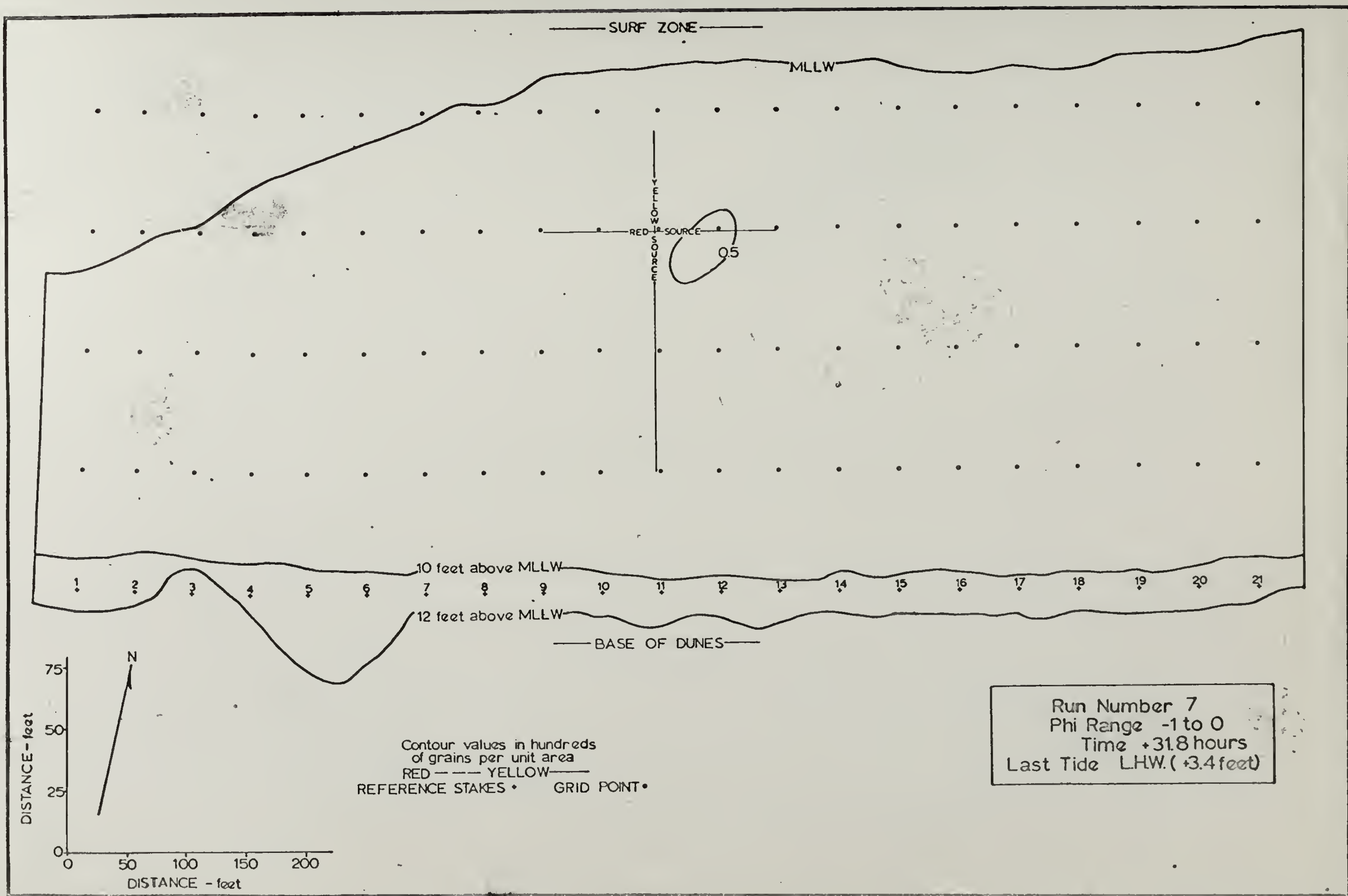


PLATE 1-3

MARKED SAND DISTRIBUTION

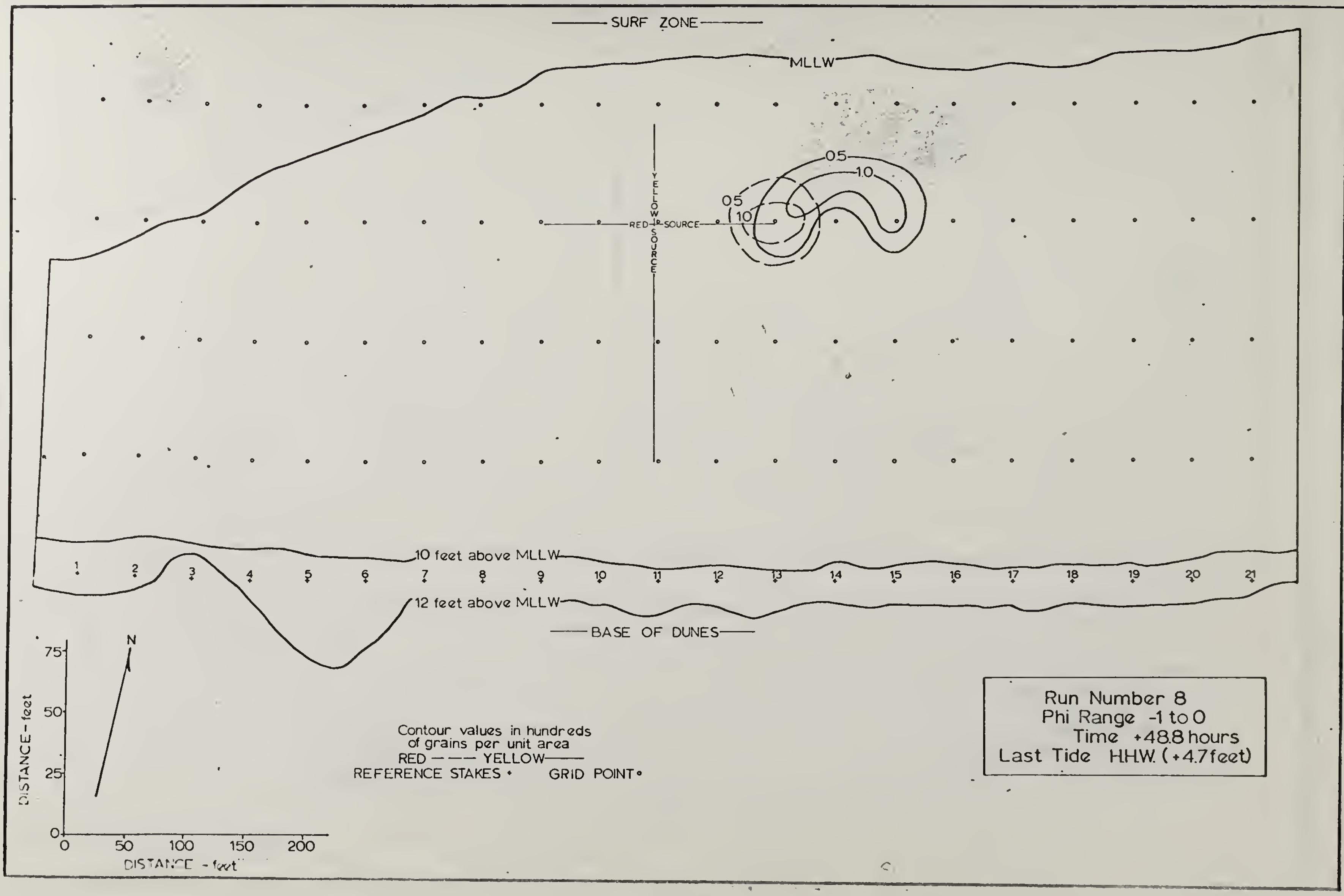


PLATE 1-4

MARKED SAND DISTRIBUTION

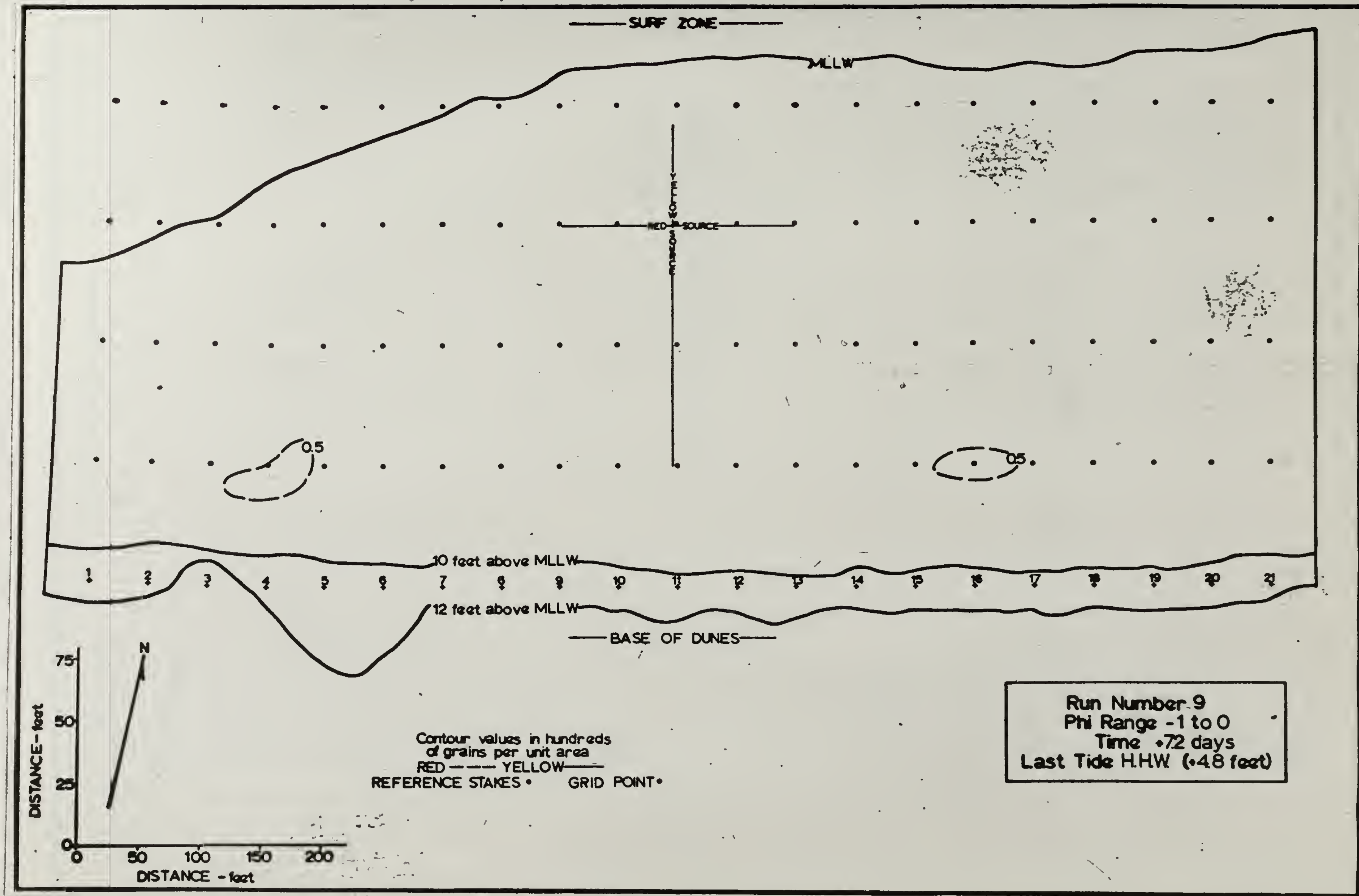


PLATE 1-5

MARKED SAND DISTRIBUTION

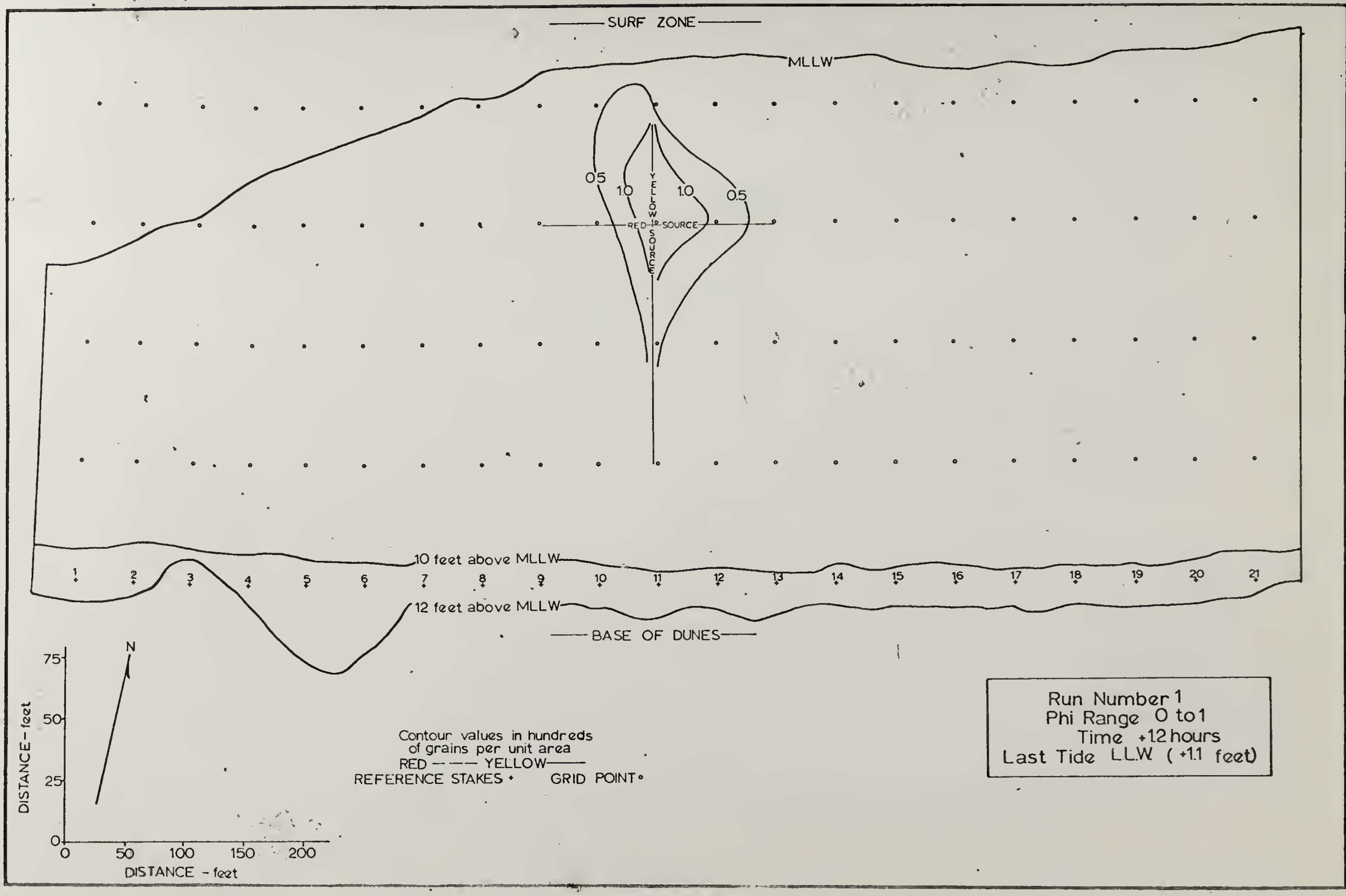


PLATE 2-1

MARKED SAND DISTRIBUTION

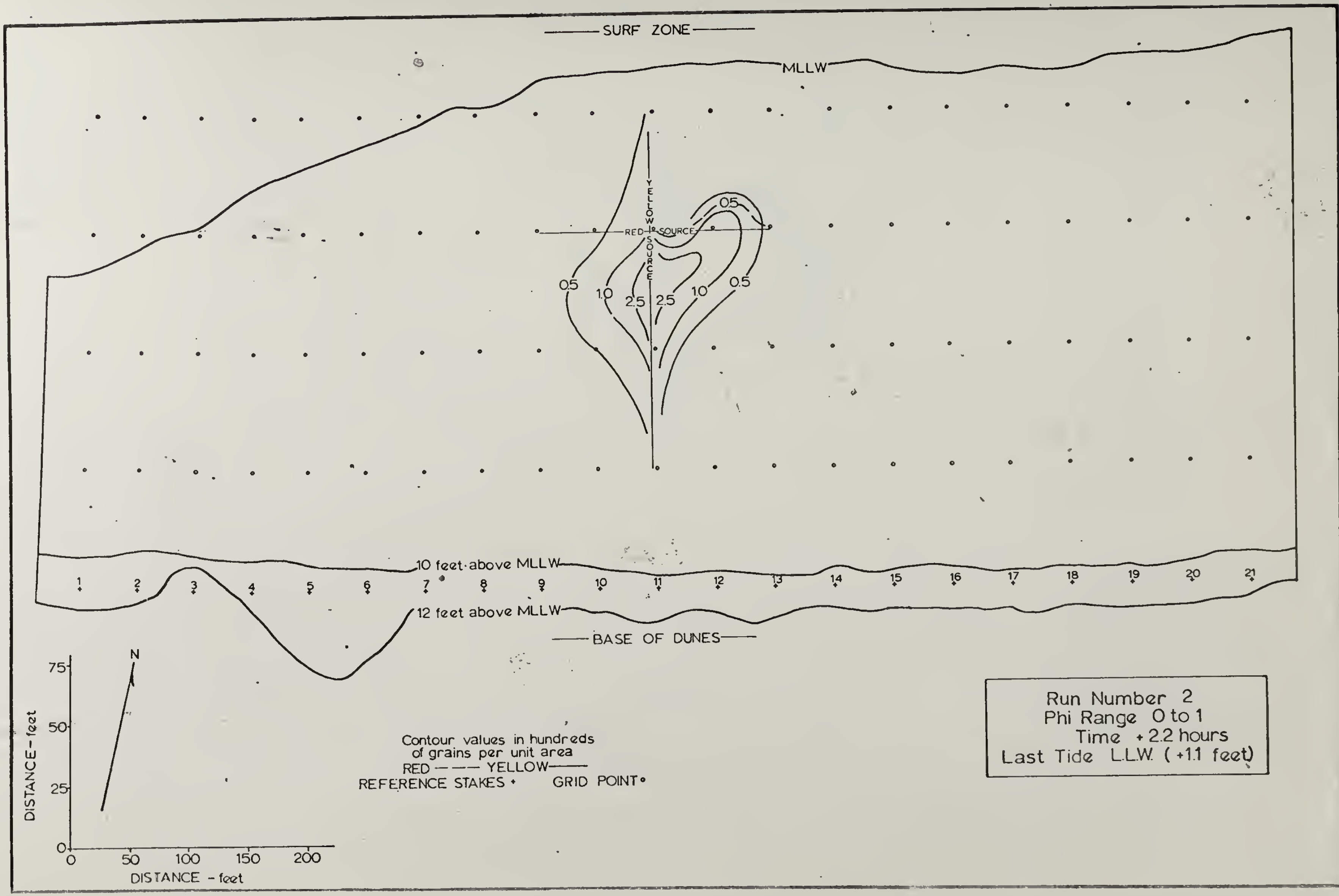


PLATE 2-2

MARKED SAND DISTRIBUTION

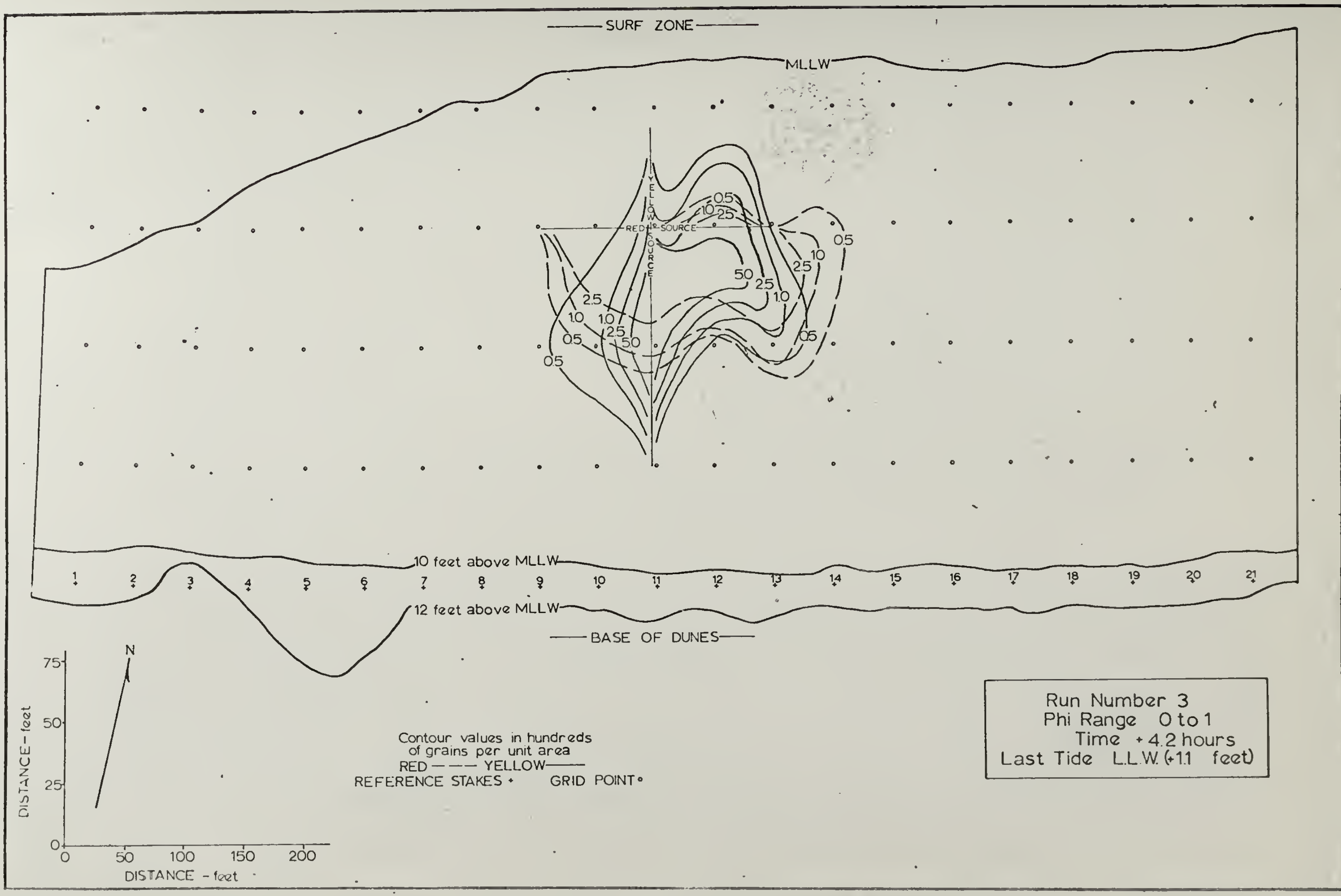


PLATE 2-3

MARKED SAND DISTRIBUTION

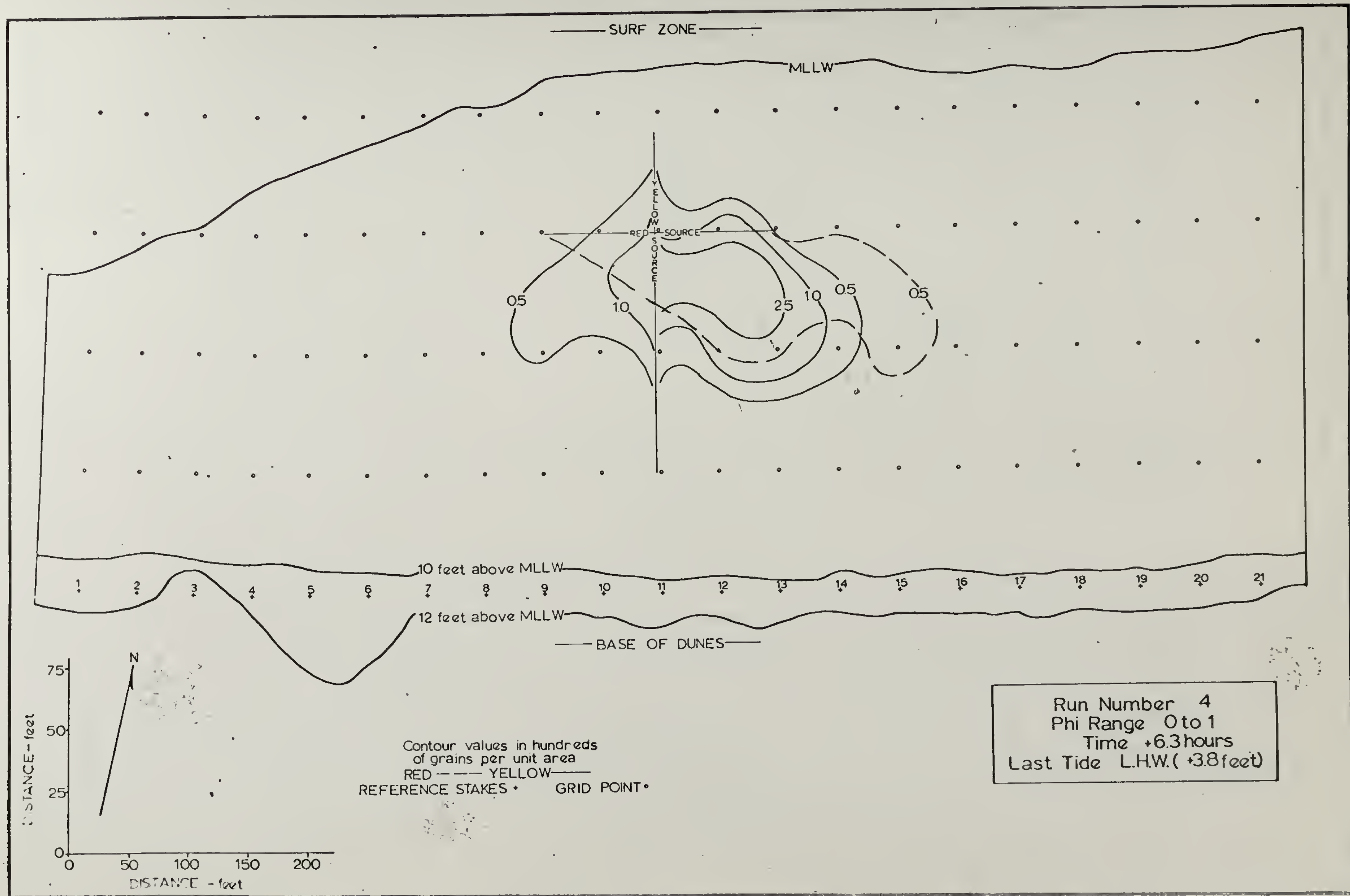


PLATE 2-4

MARKED SAND DISTRIBUTION

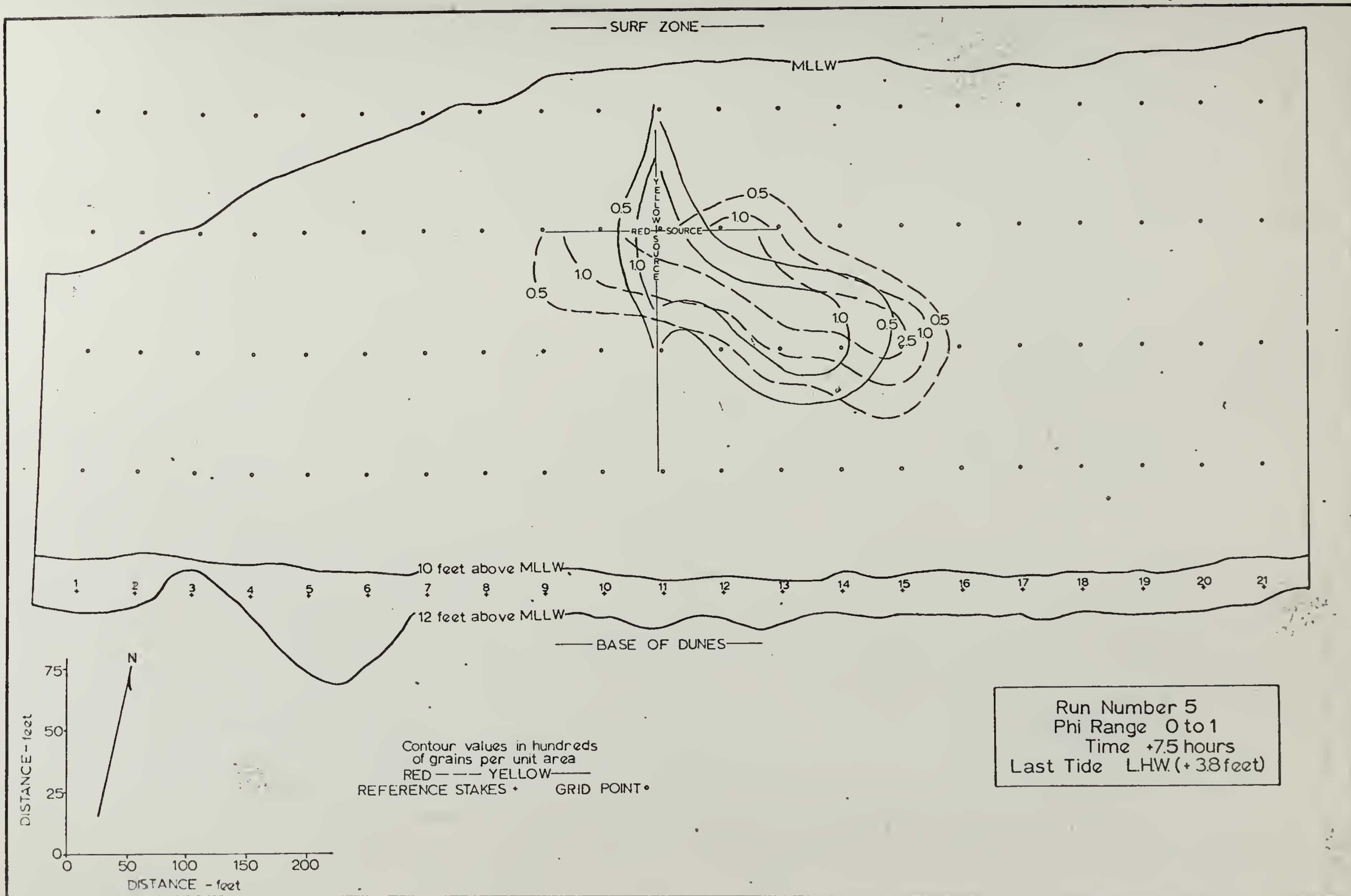


PLATE 2-5

MARKED SAND DISTRIBUTION

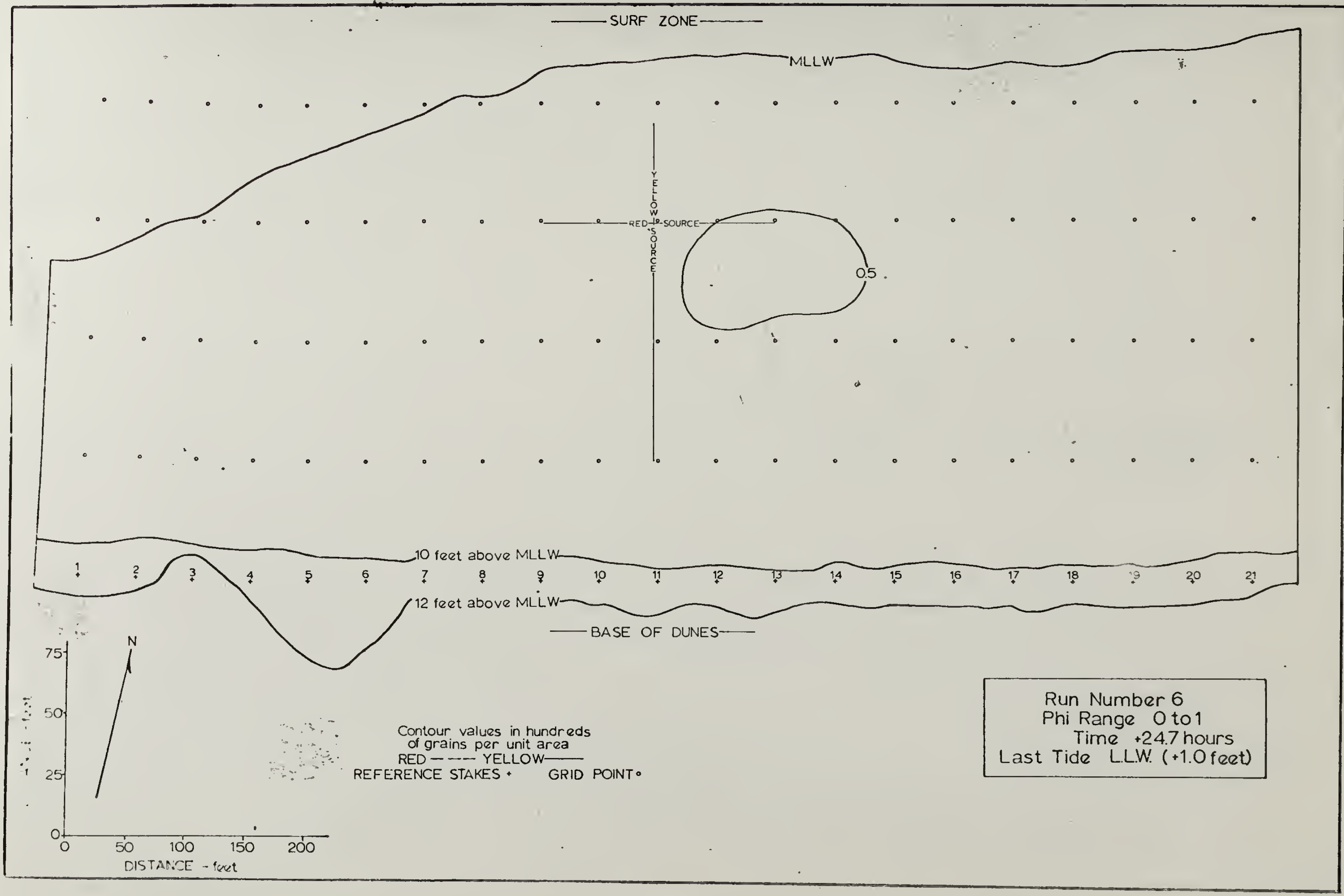


PLATE 2-6

MARKED SAND DISTRIBUTION

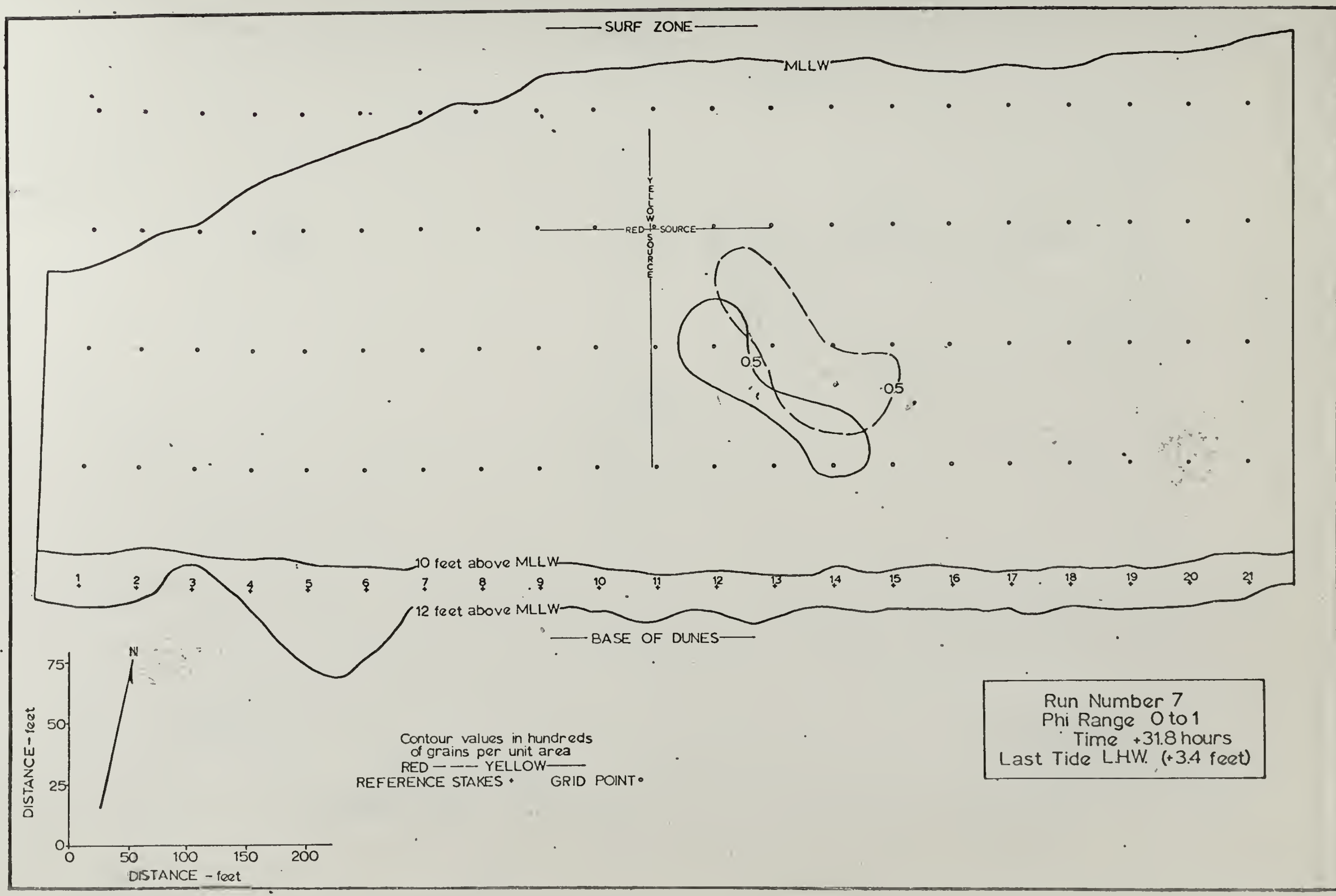


PLATE 2-7

MARKED SAND DISTRIBUTION

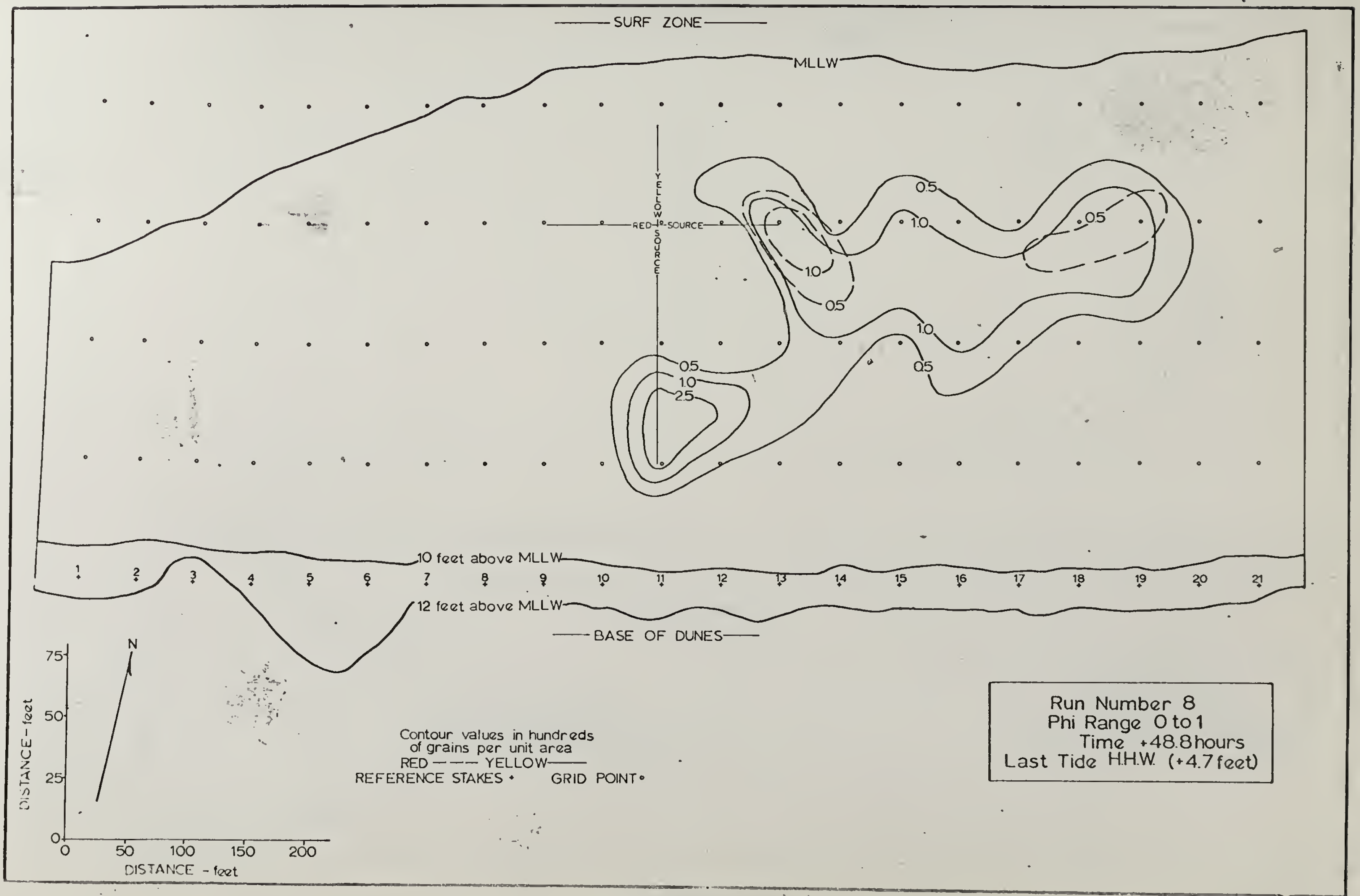


PLATE 2-8

MARKED SAND DISTRIBUTION

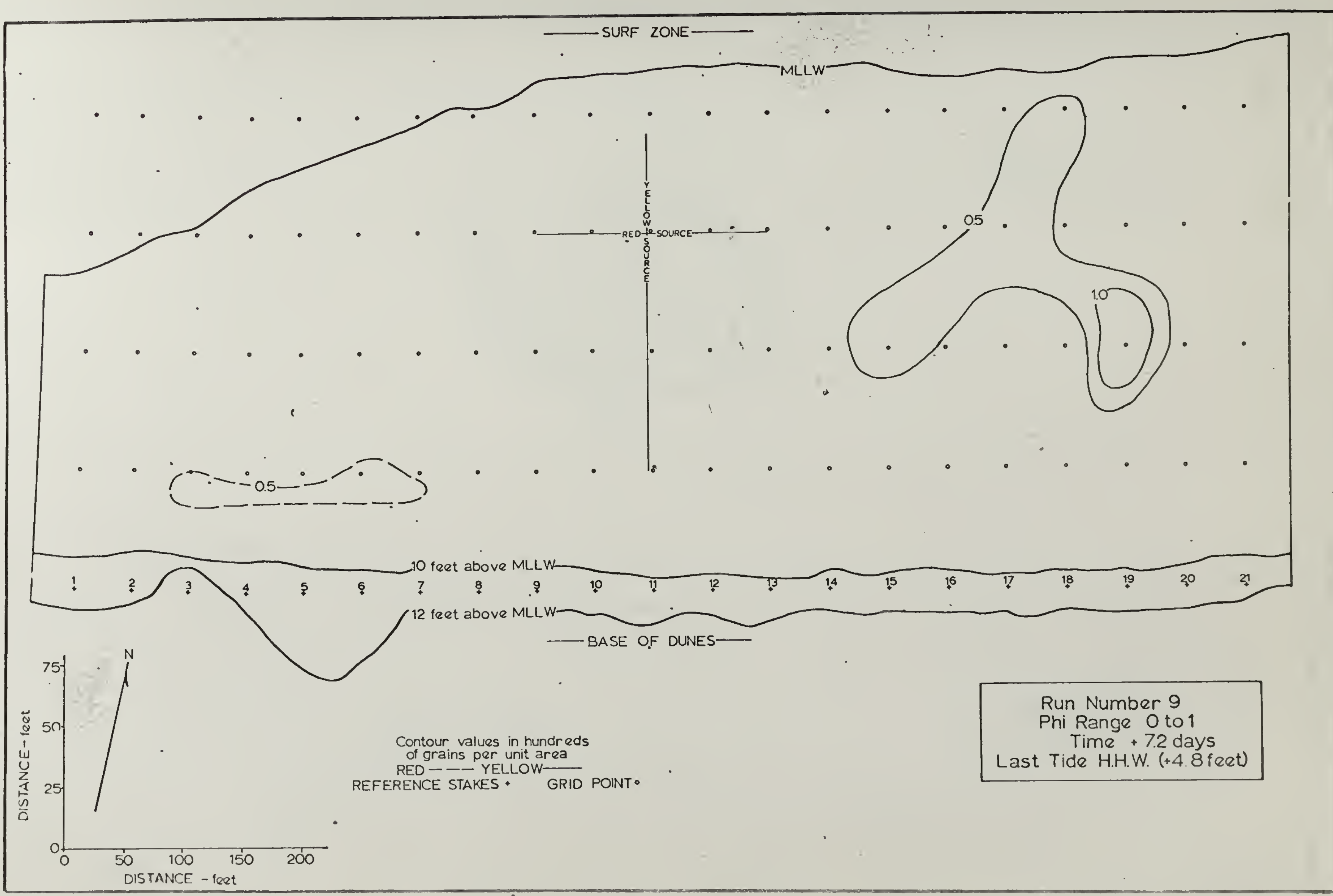


PLATE 2-9

MARKED SAND DISTRIBUTION

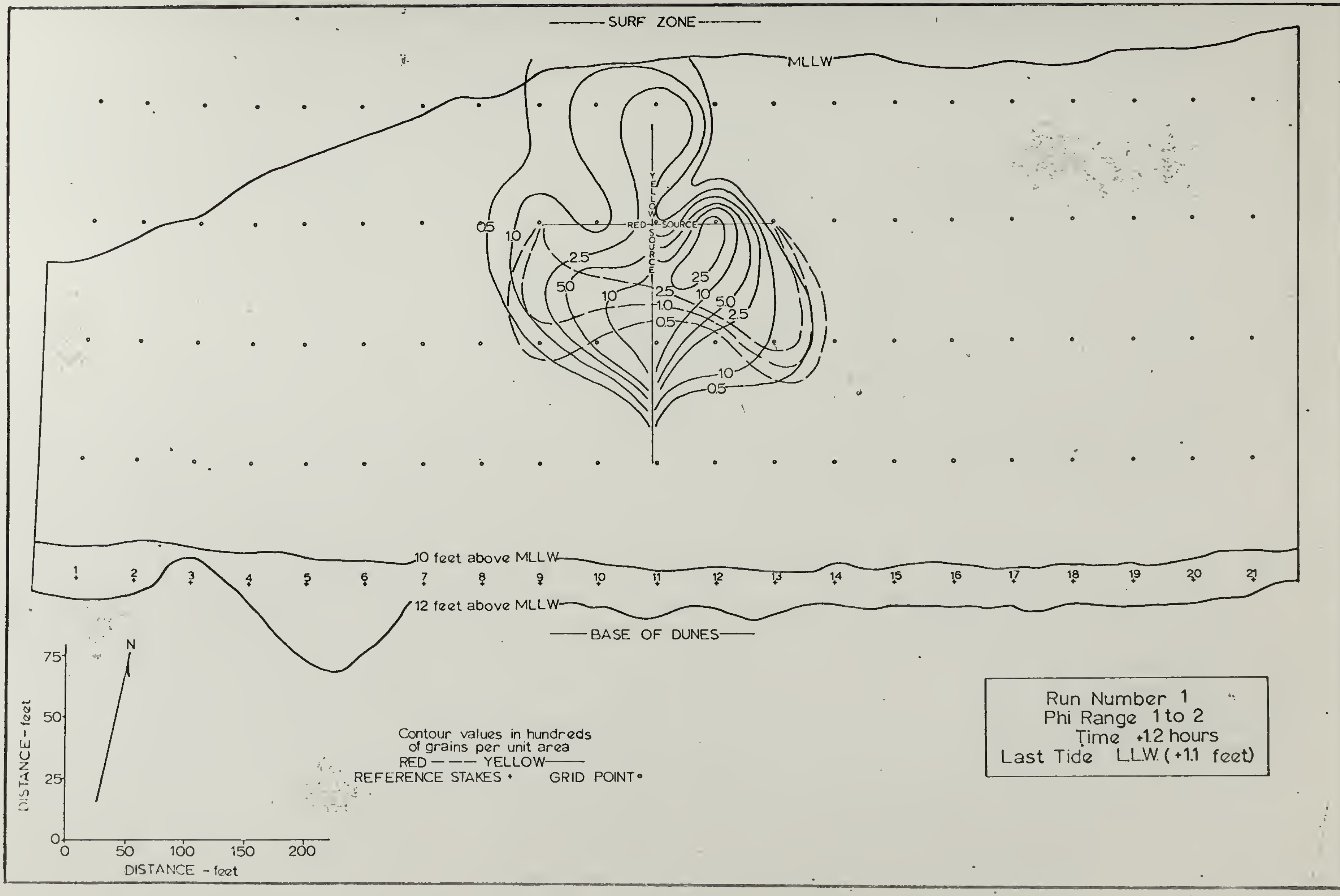


PLATE 3-1

MARKED SAND DISTRIBUTION

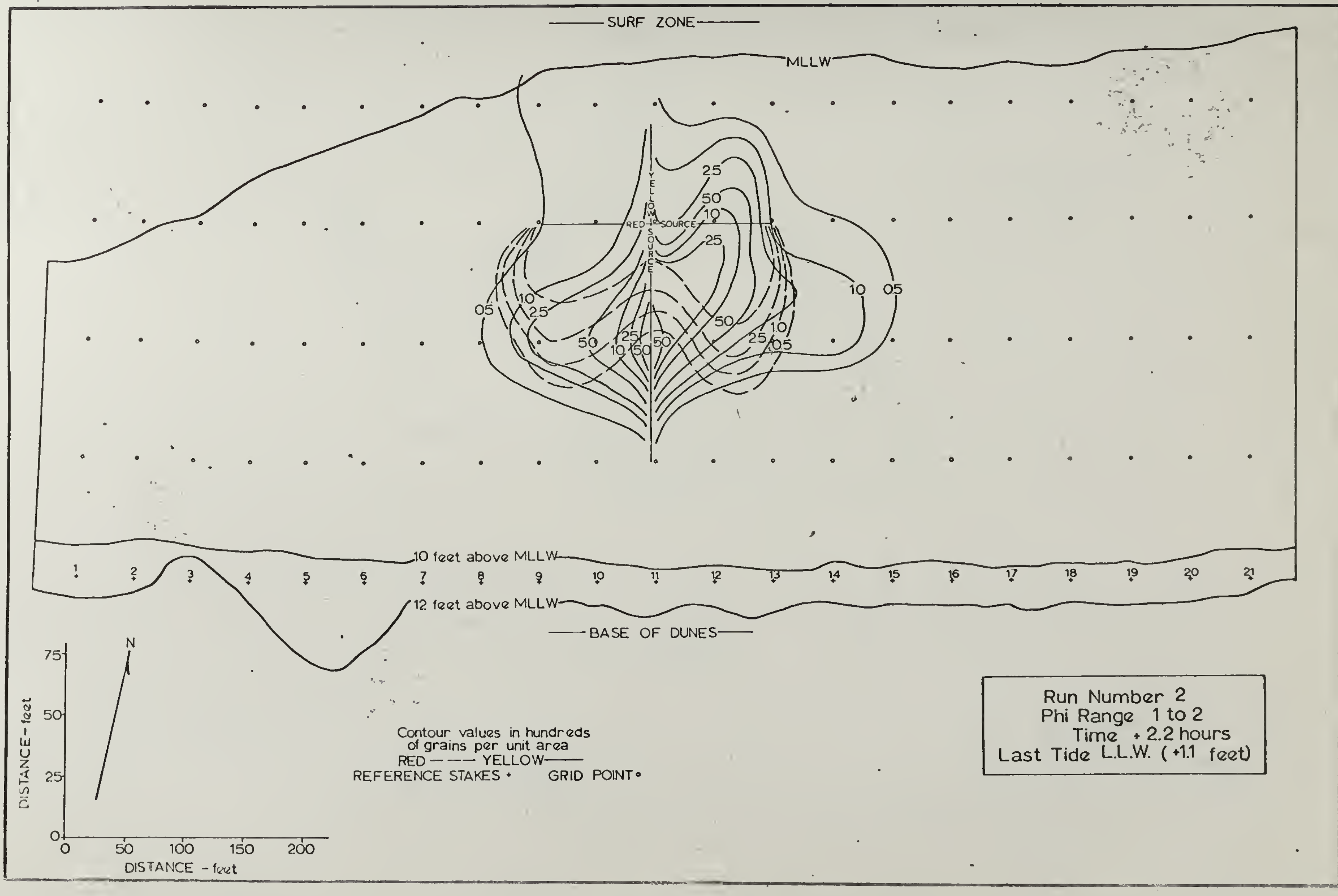


PLATE 3-2

MARKED SAND DISTRIBUTION

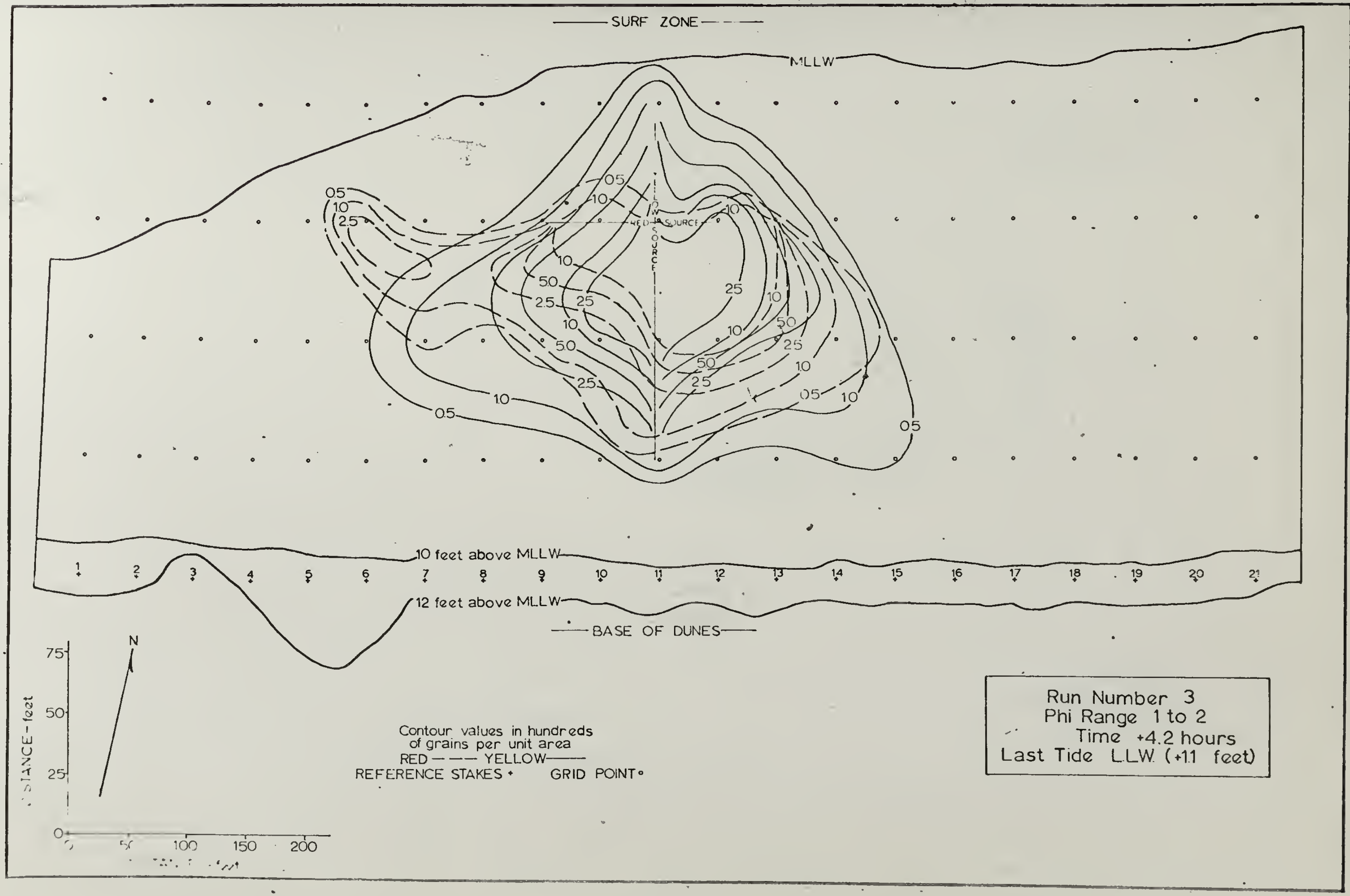


PLATE 3-3

MARKED SAND DISTRIBUTION

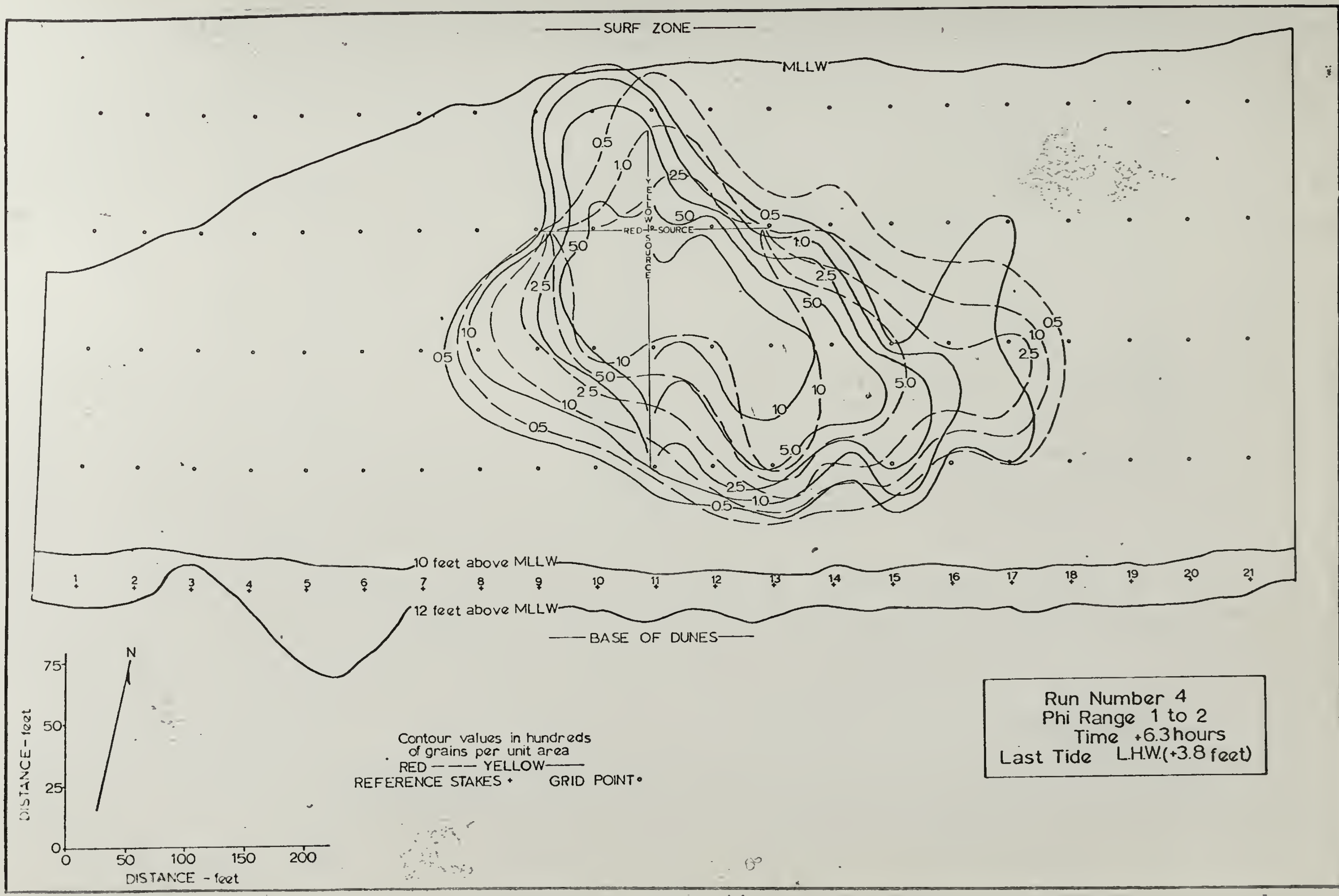


PLATE 3-4

MARKED SAND DISTRIBUTION

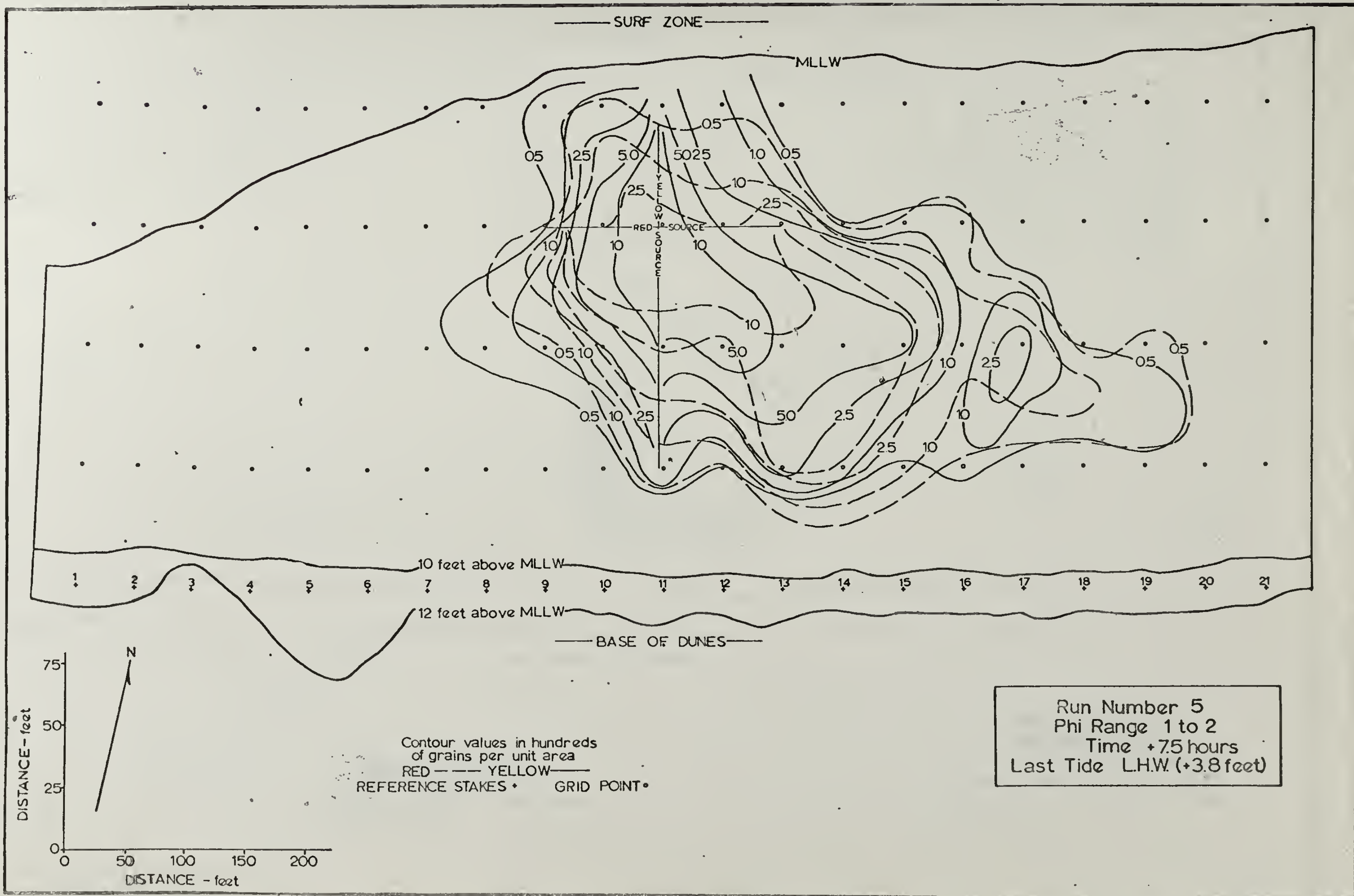


PLATE 3-5

MARKED SAND DISTRIBUTION

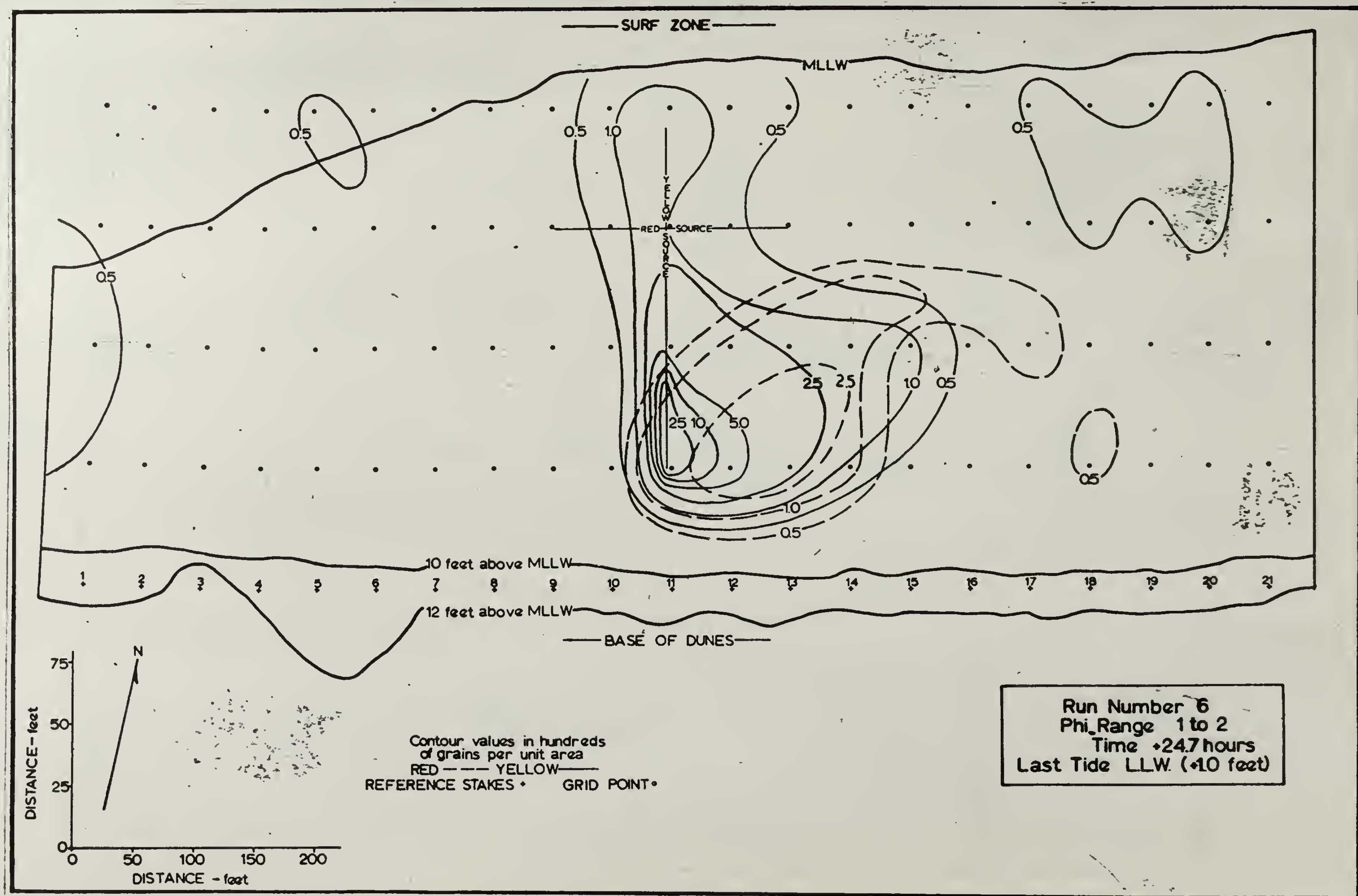


PLATE 3-6

MARKED SAND DISTRIBUTION

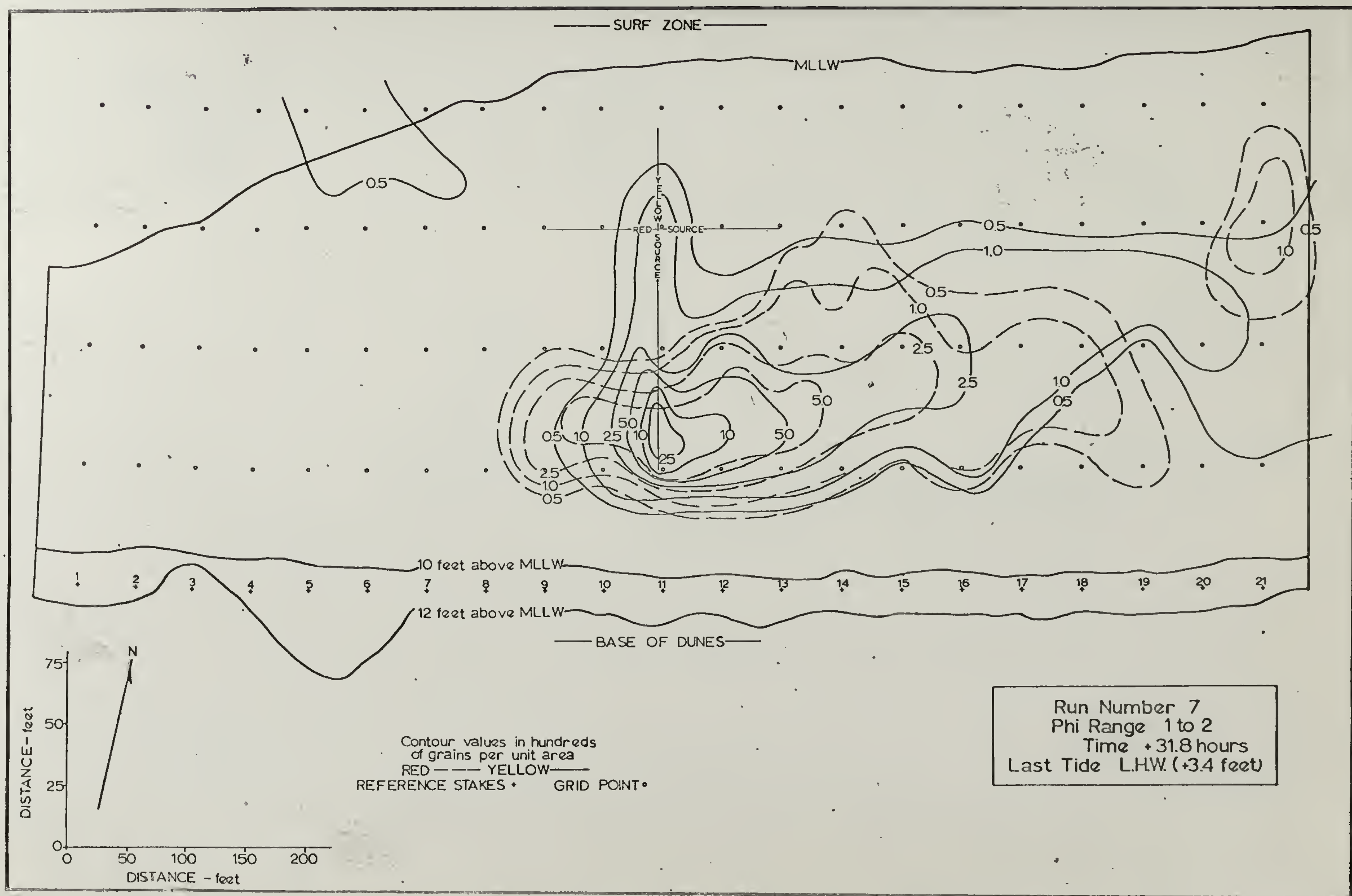


PLATE 3-7

MARKED SAND DISTRIBUTION

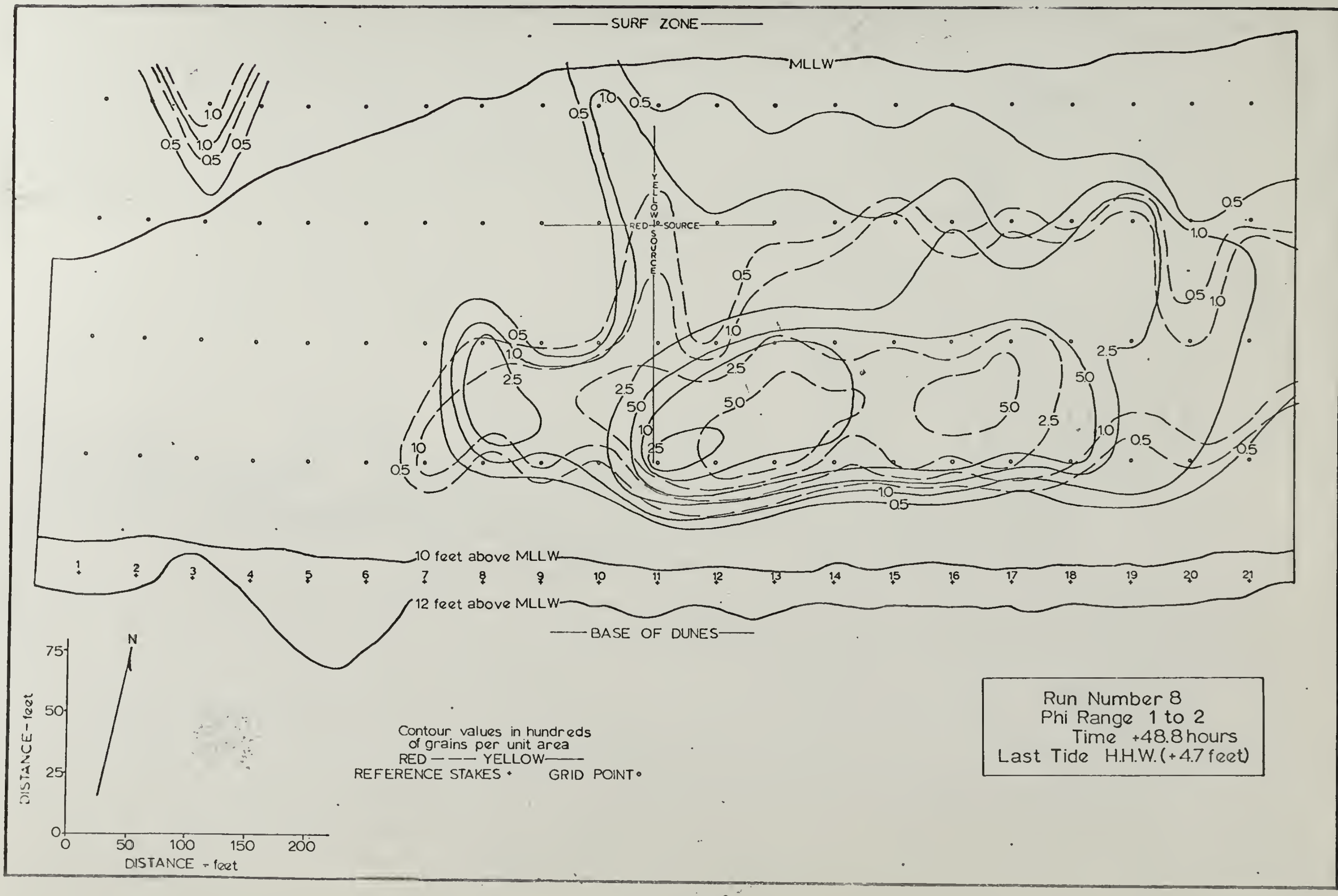


PLATE 3-8

MARKED SAND DISTRIBUTION

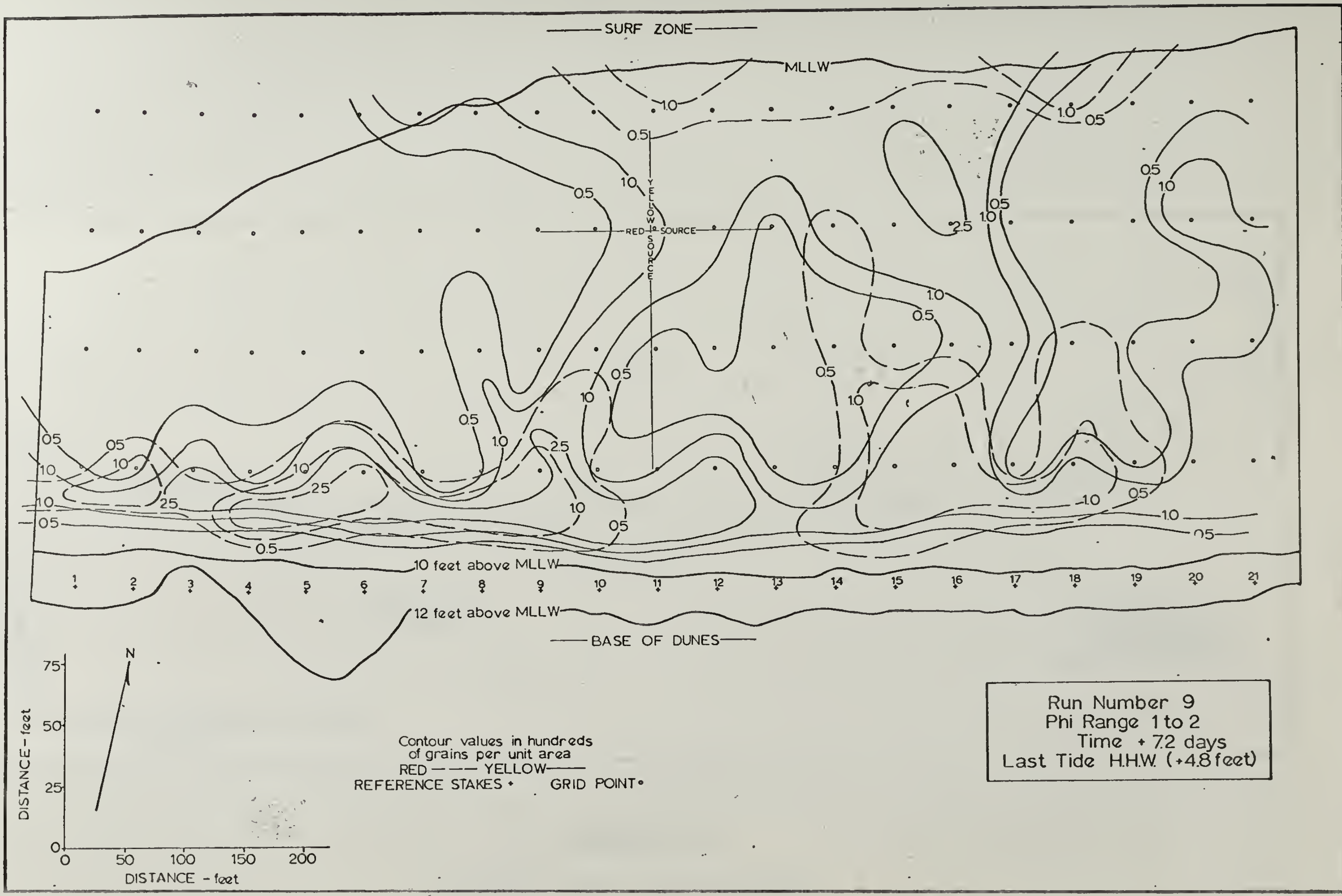


PLATE 3-9

MARKED SAND DISTRIBUTION

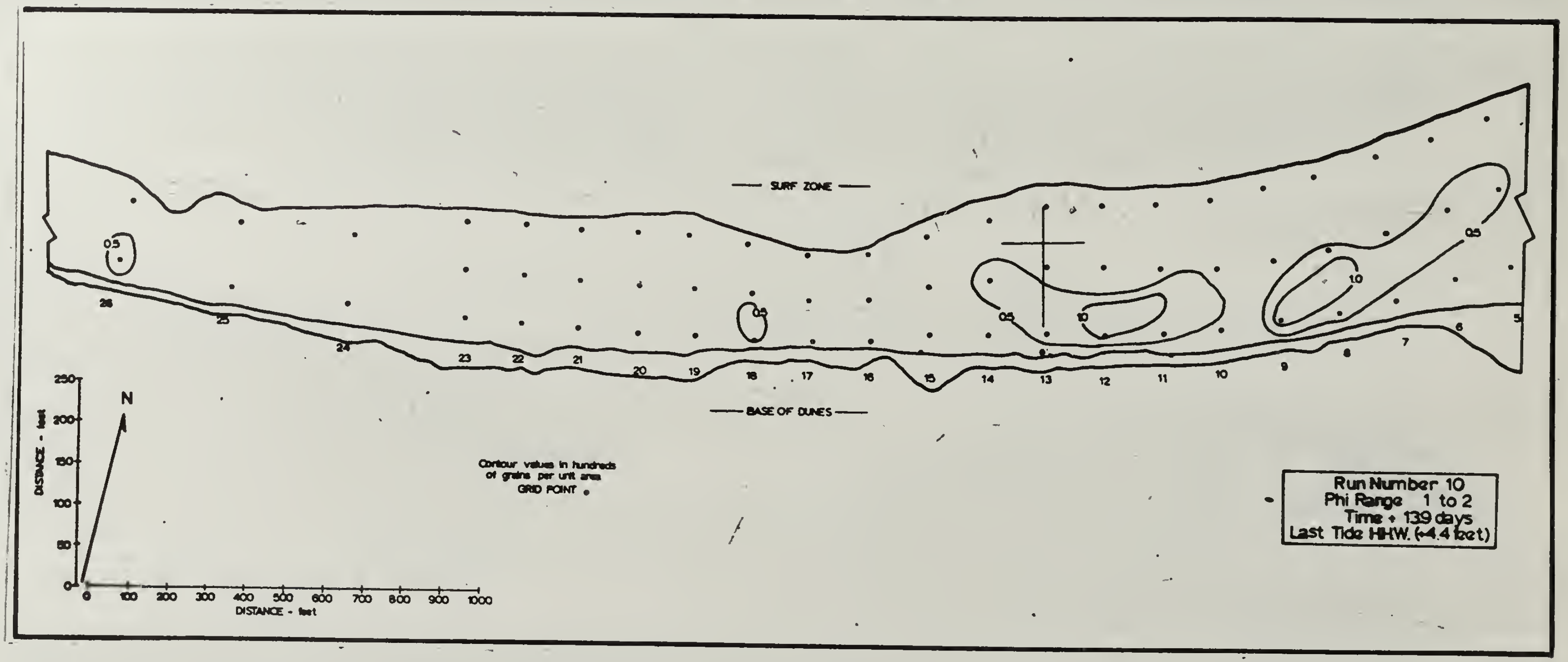
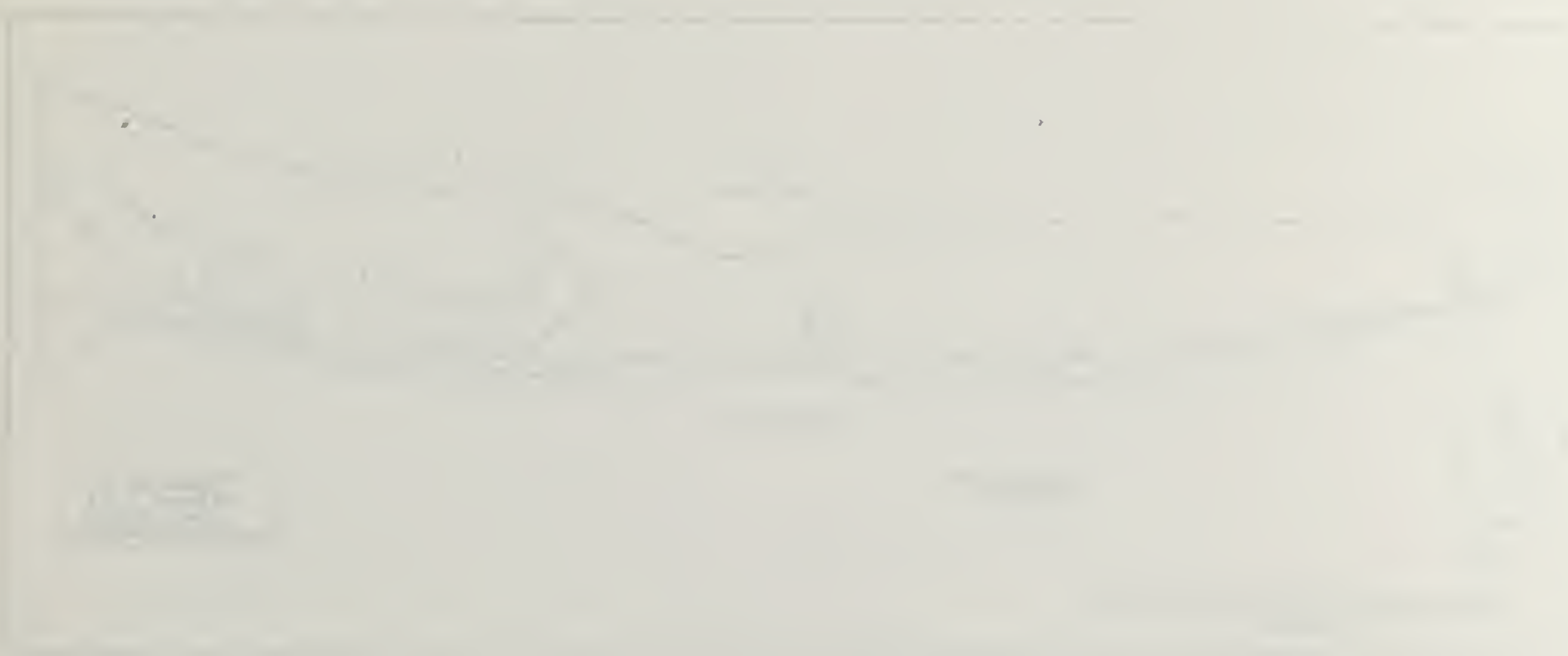


PLATE 3-10

MARKED SAND DISTRIBUTION



[illegible]

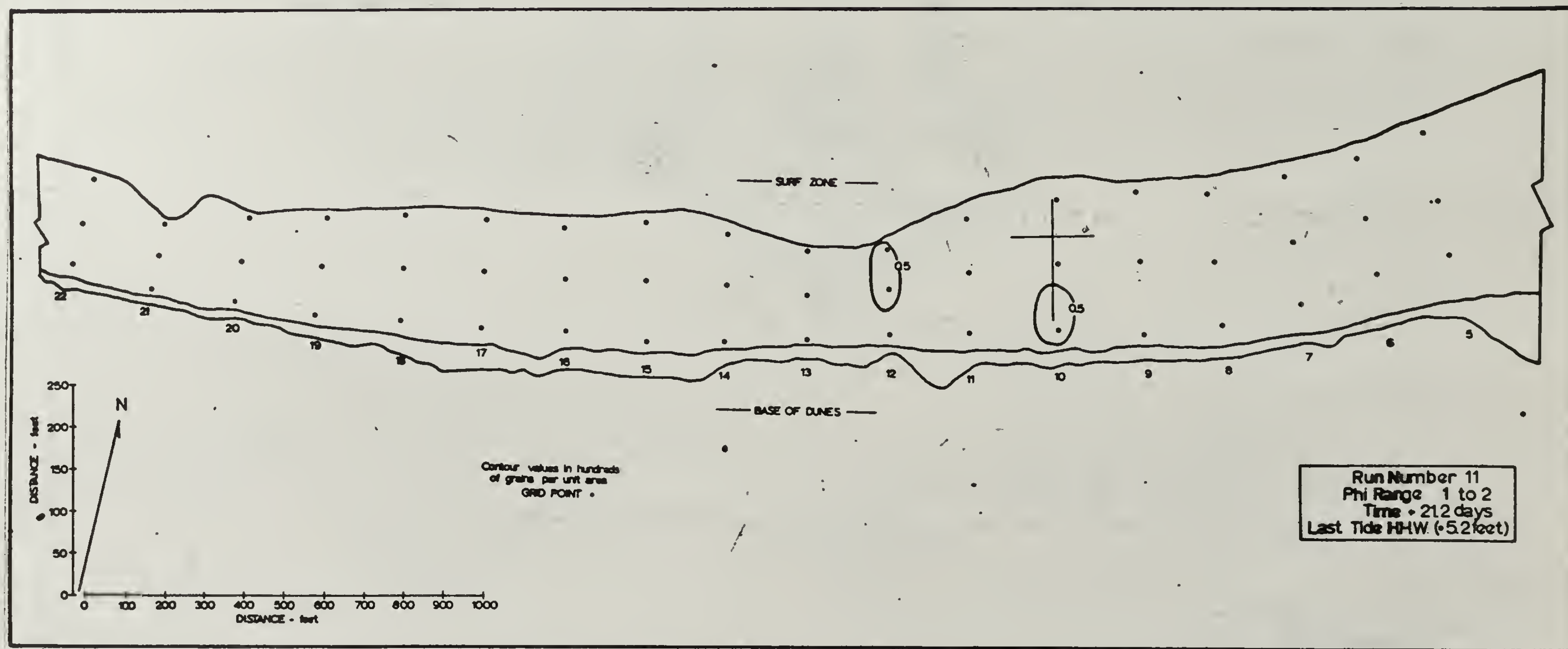


PLATE 3-11

MARKED SAND DISTRIBUTION

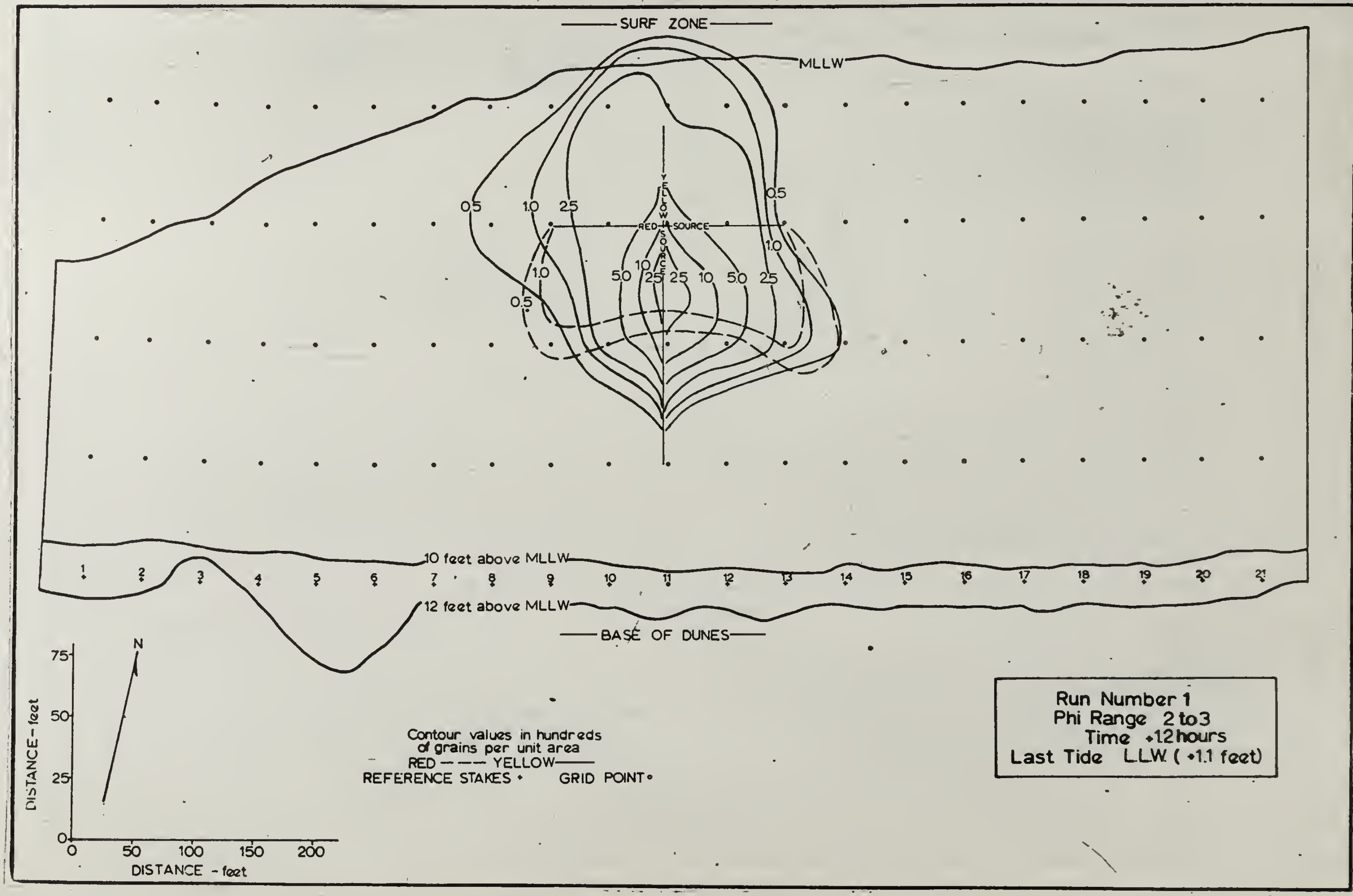


PLATE 4-1

MARKED SAND DISTRIBUTION

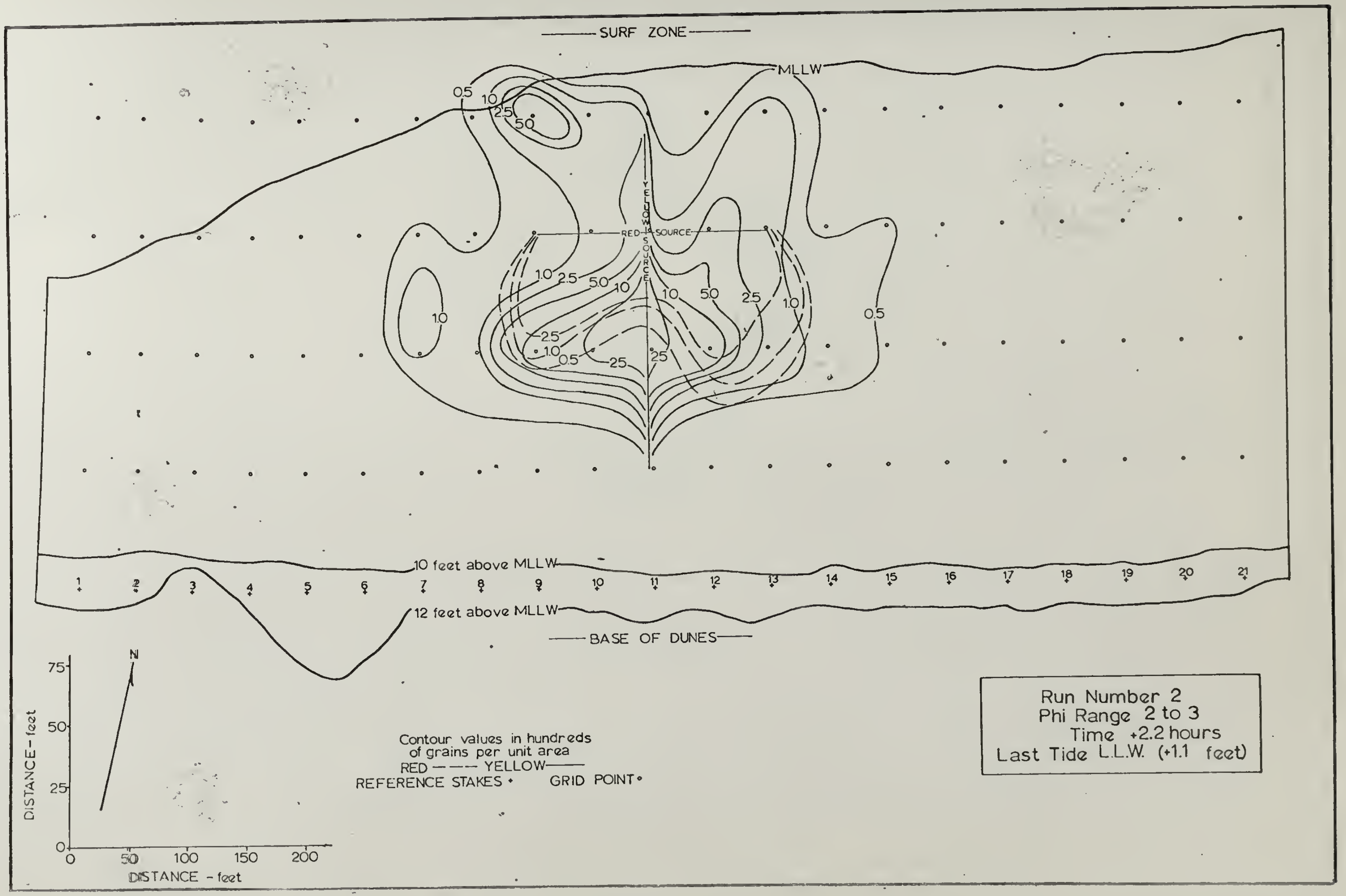


PLATE 4-2

MARKED SAND DISTRIBUTION

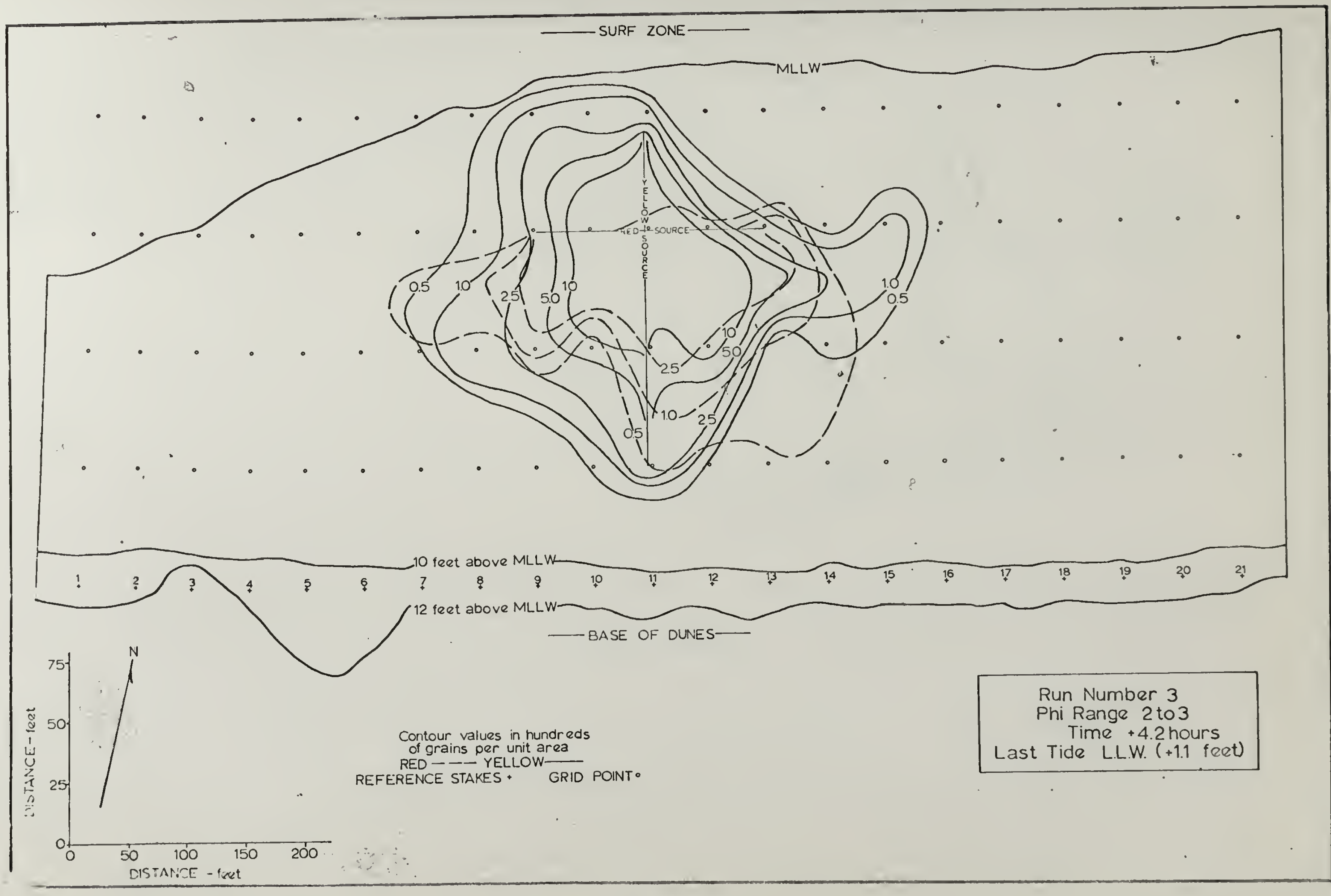


PLATE 4-3

MARKED SAND DISTRIBUTION

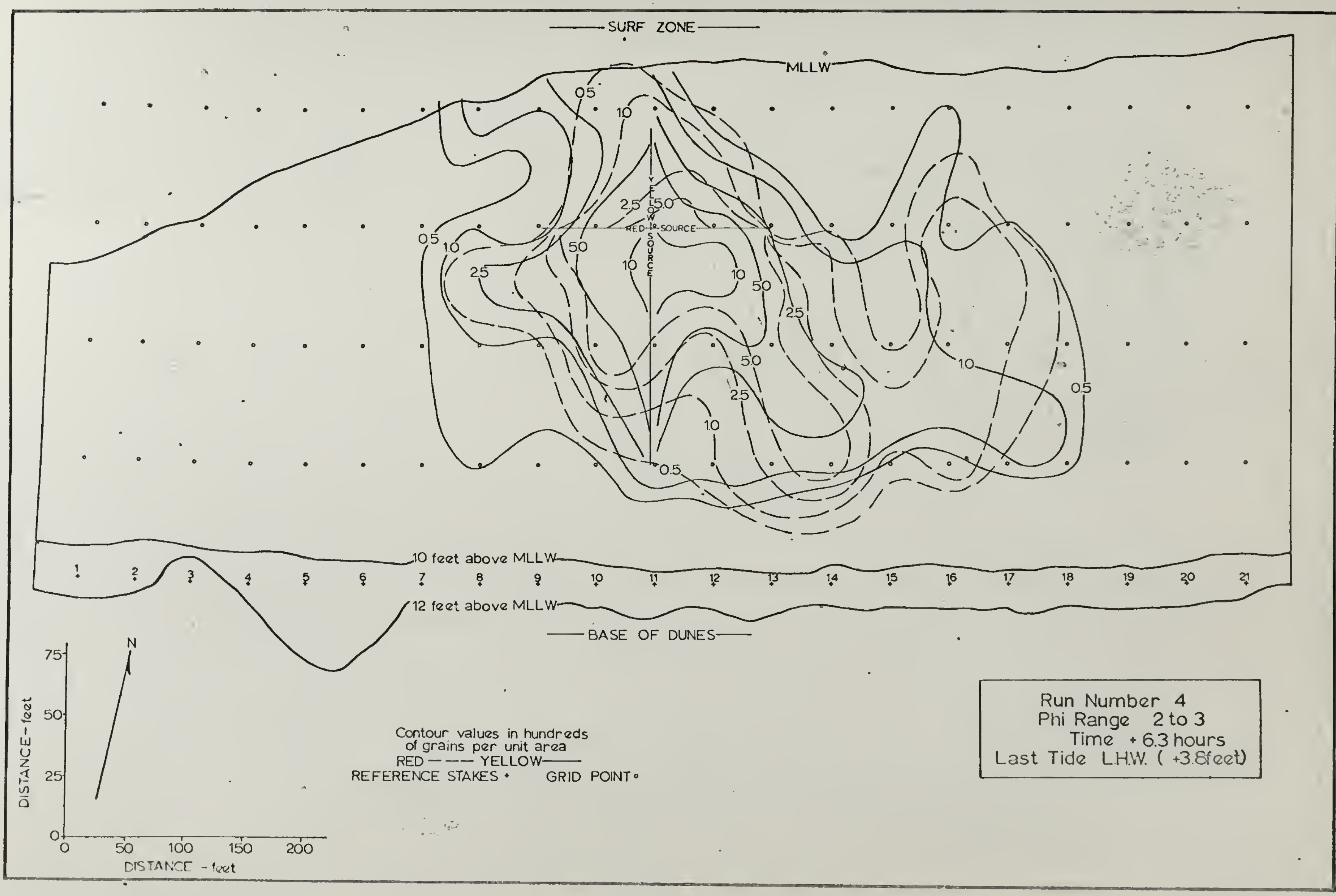


PLATE 4-4

MARKED SAND DISTRIBUTION

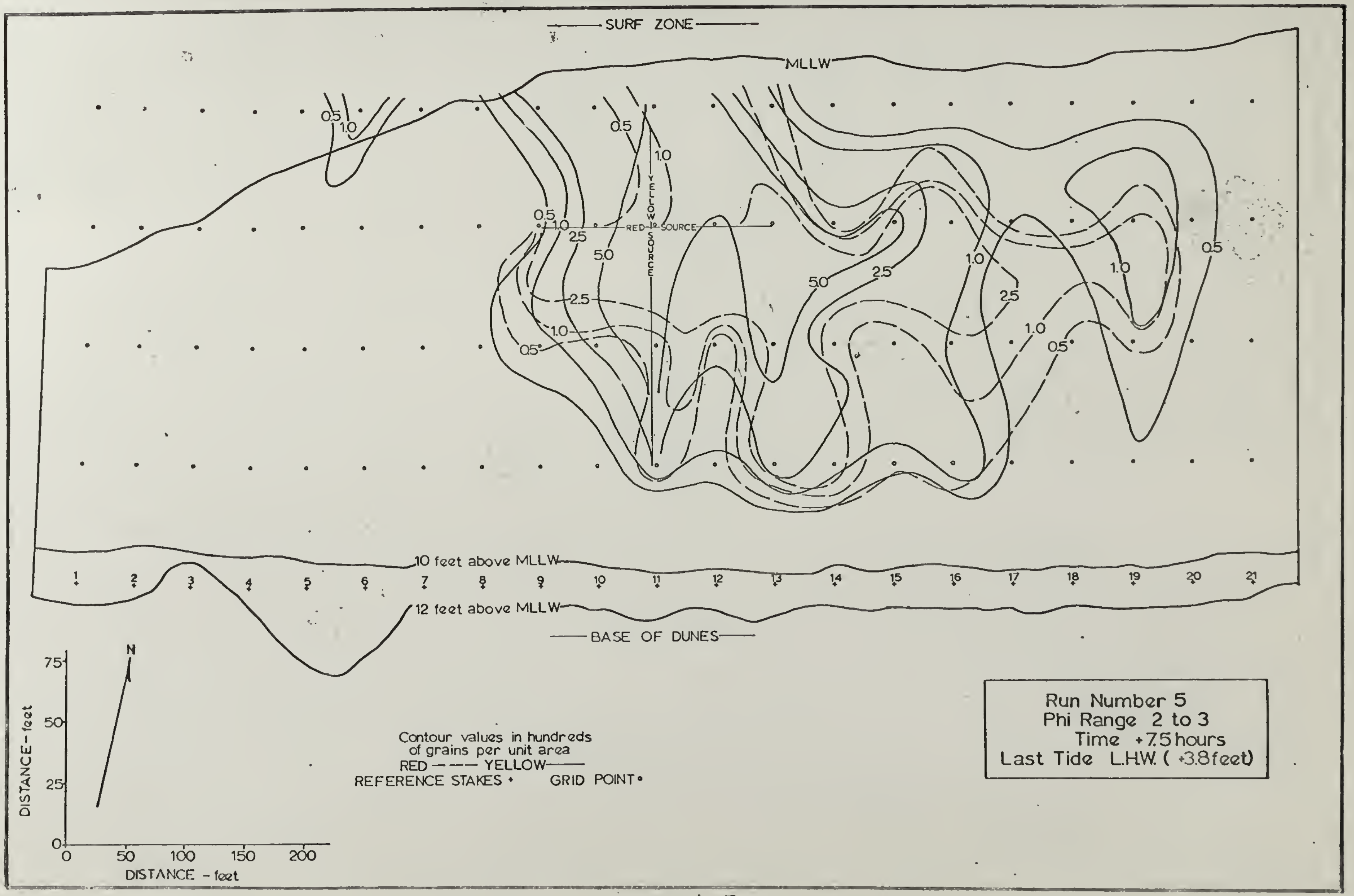


PLATE 4-5

MARKED SAND DISTRIBUTION

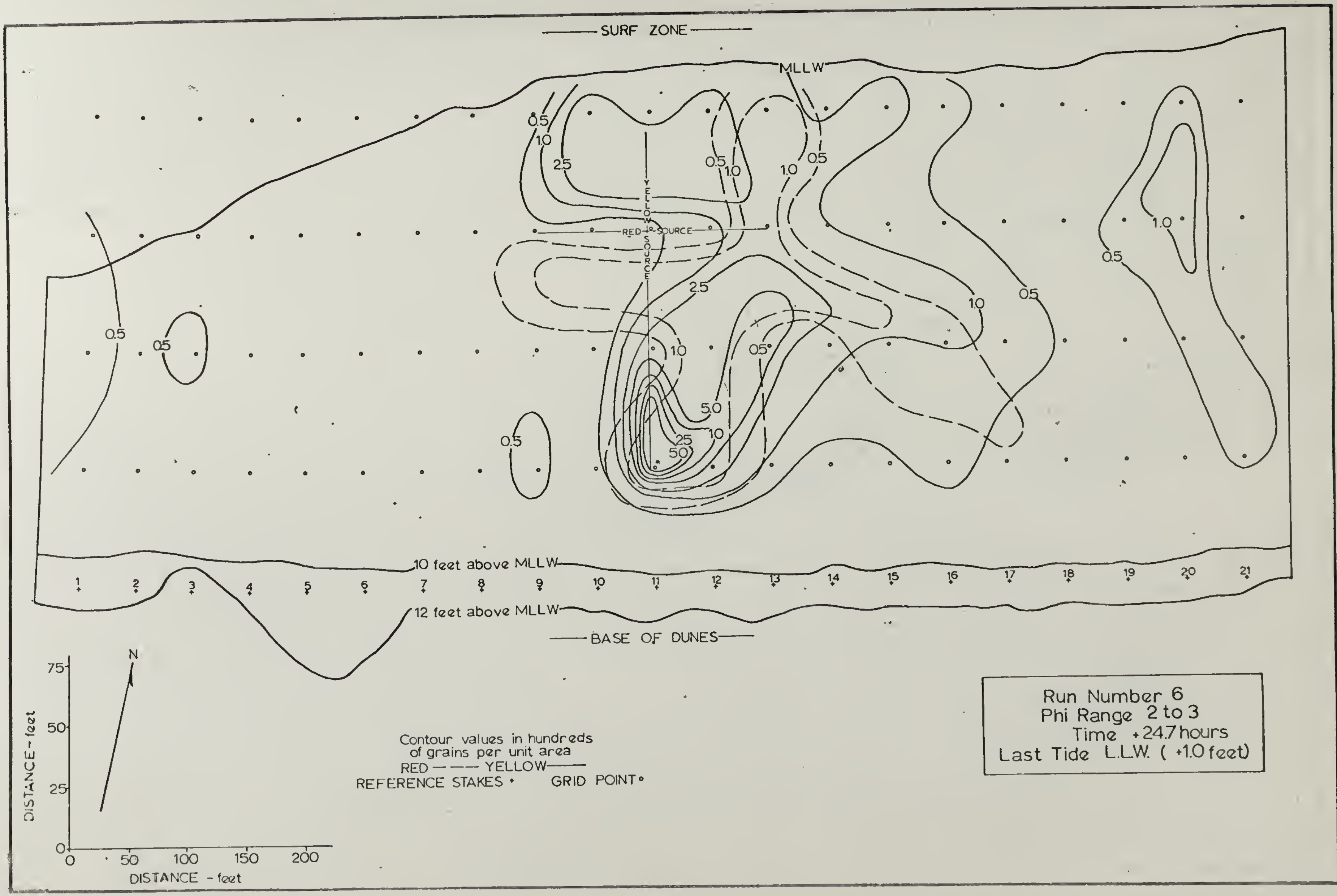


PLATE 4-6

MARKED SAND DISTRIBUTION

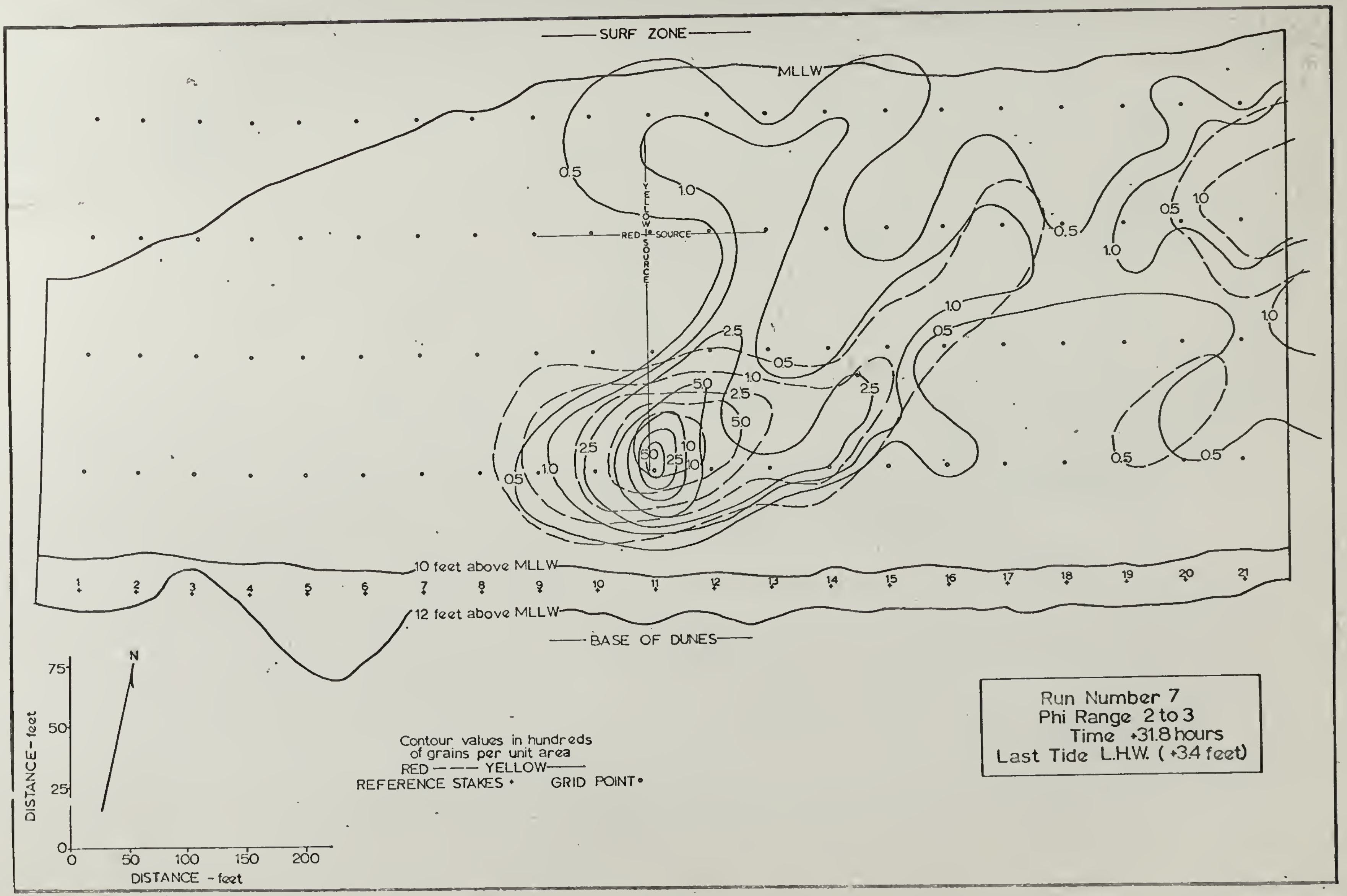


PLATE 4-7

MARKED SAND DISTRIBUTION

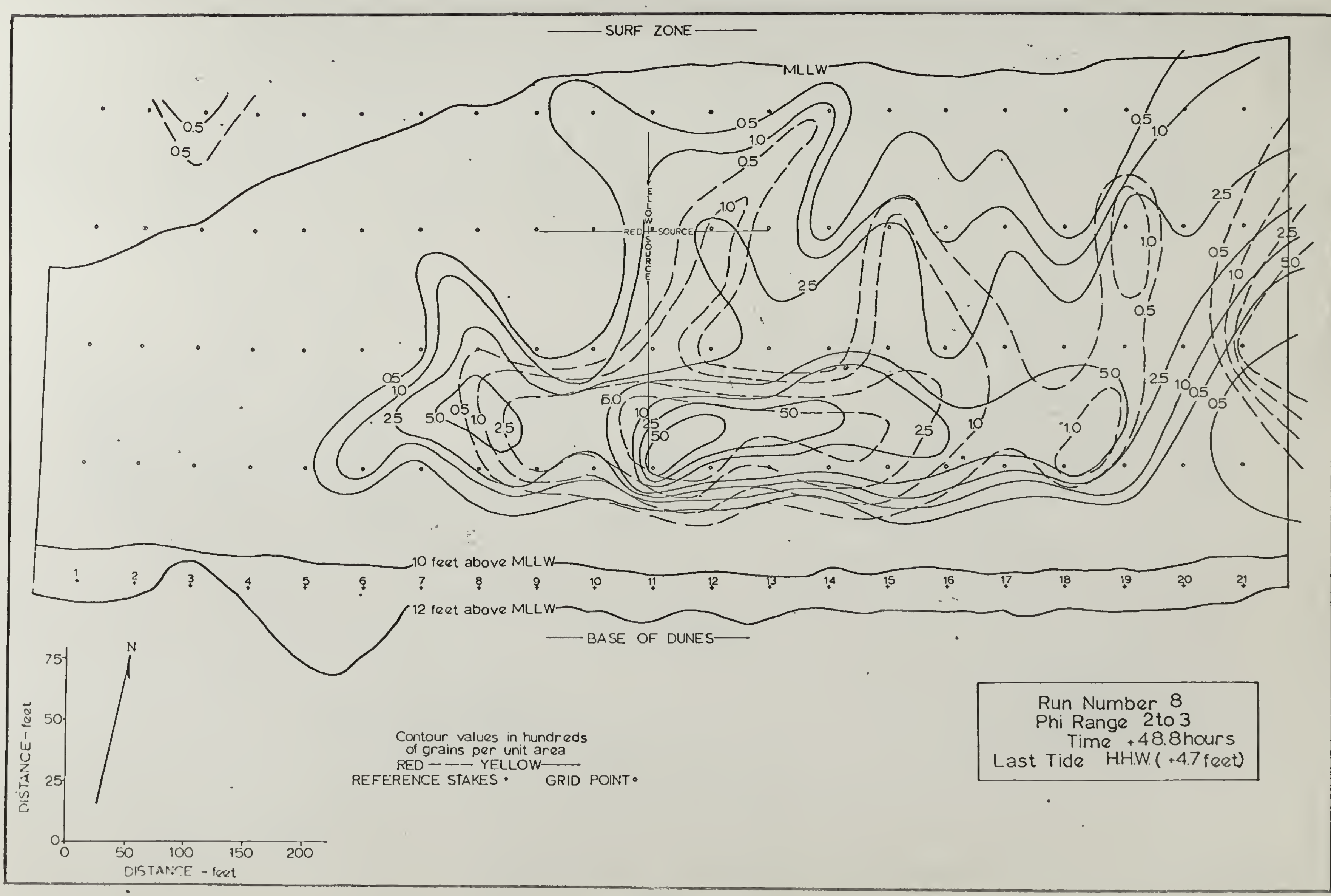


PLATE 4-8

MARKED SAND DISTRIBUTION

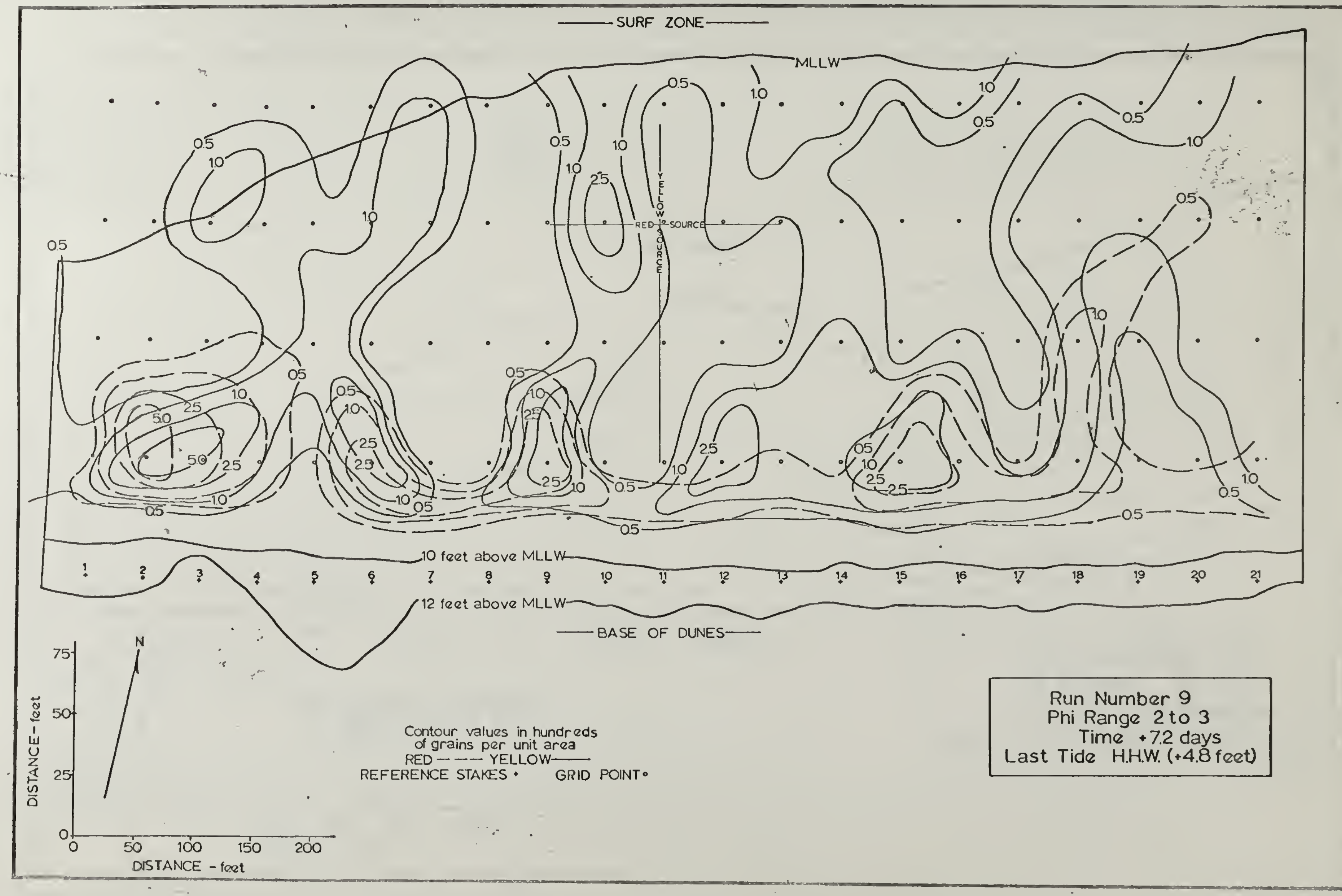


PLATE 4-9

MARKED SAND DISTRIBUTION

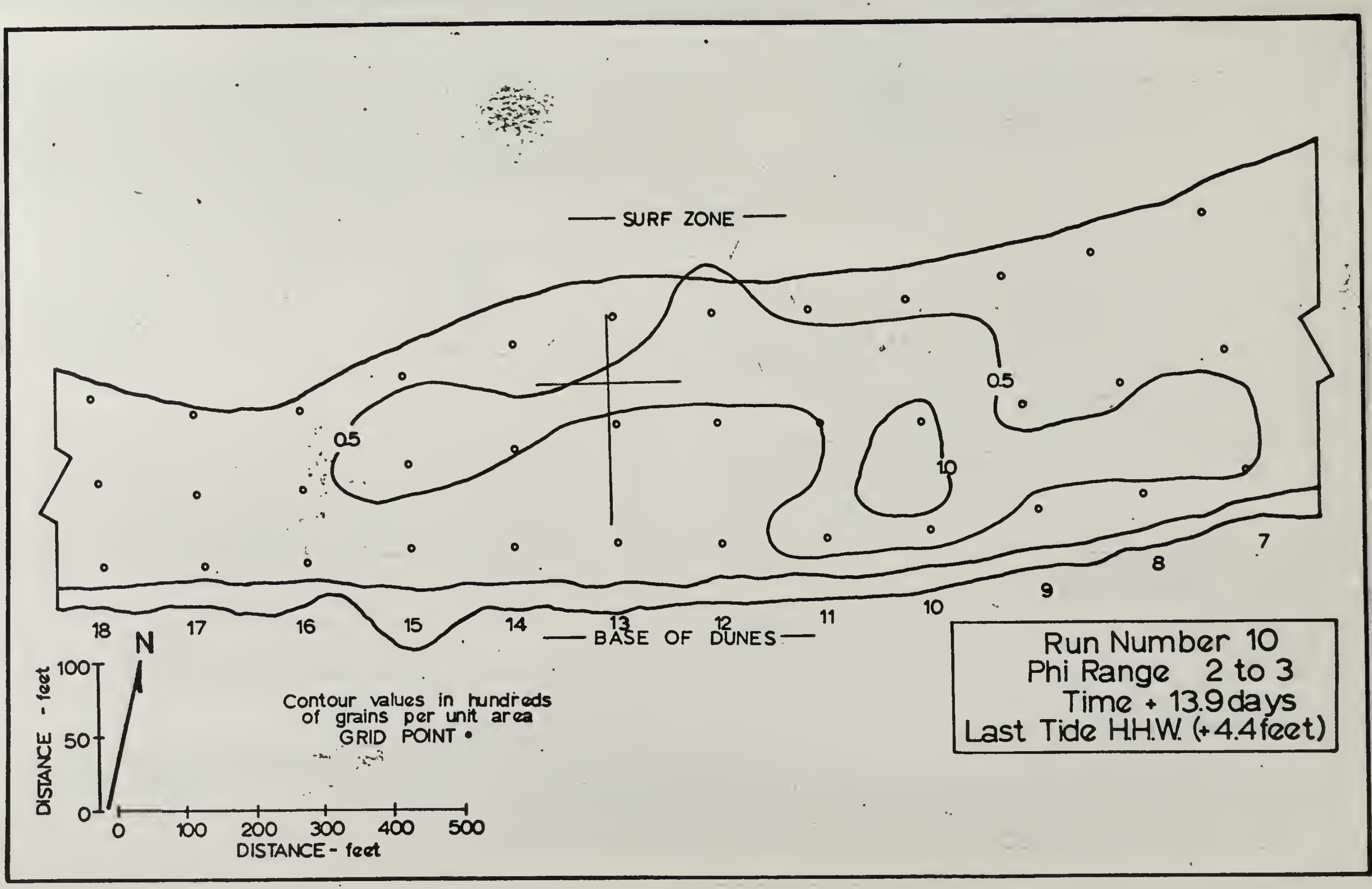


PLATE 4-10

MARKED SAND DISTRIBUTION

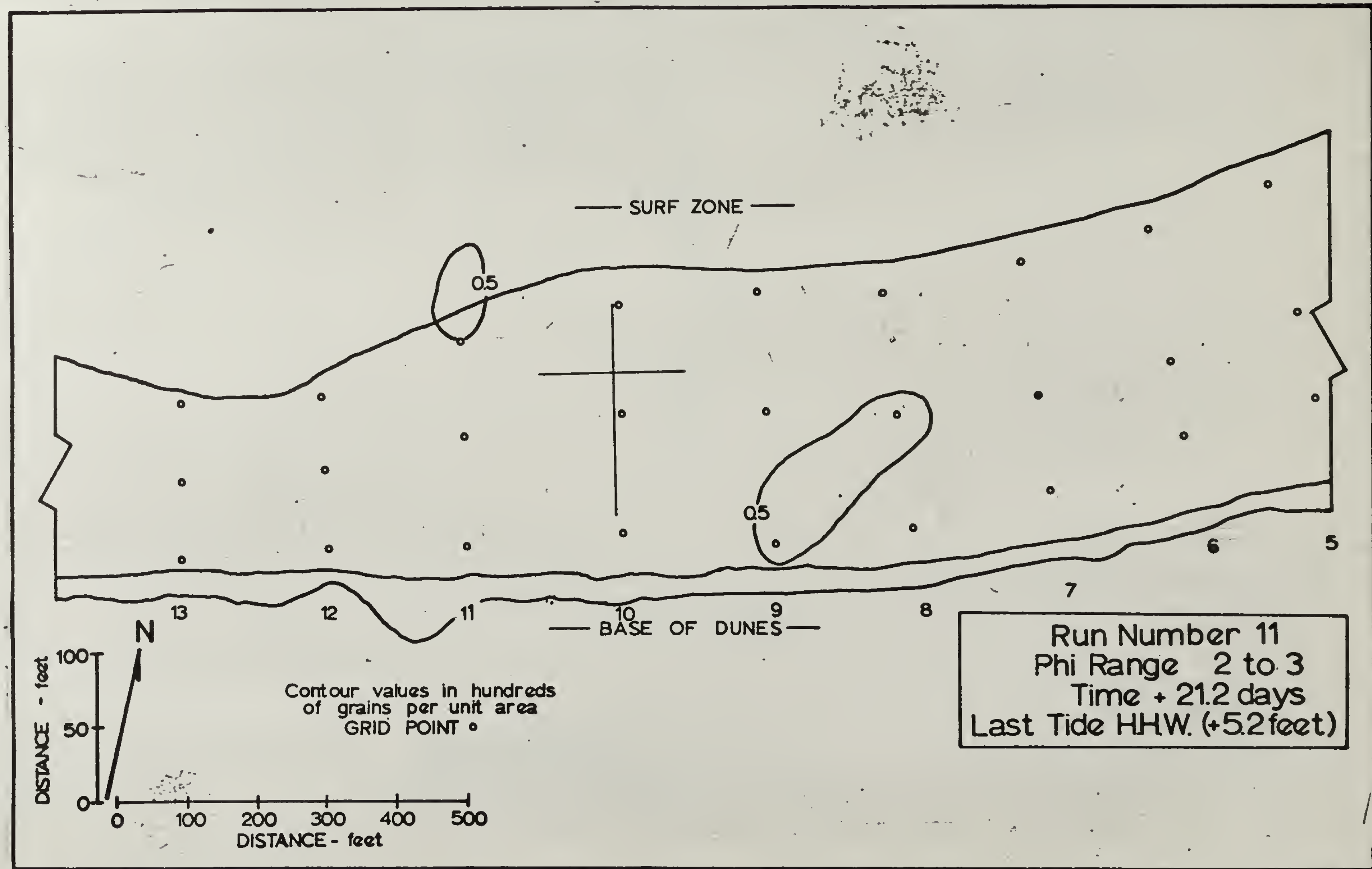


PLATE 4-11

MARKED SAND DISTRIBUTION

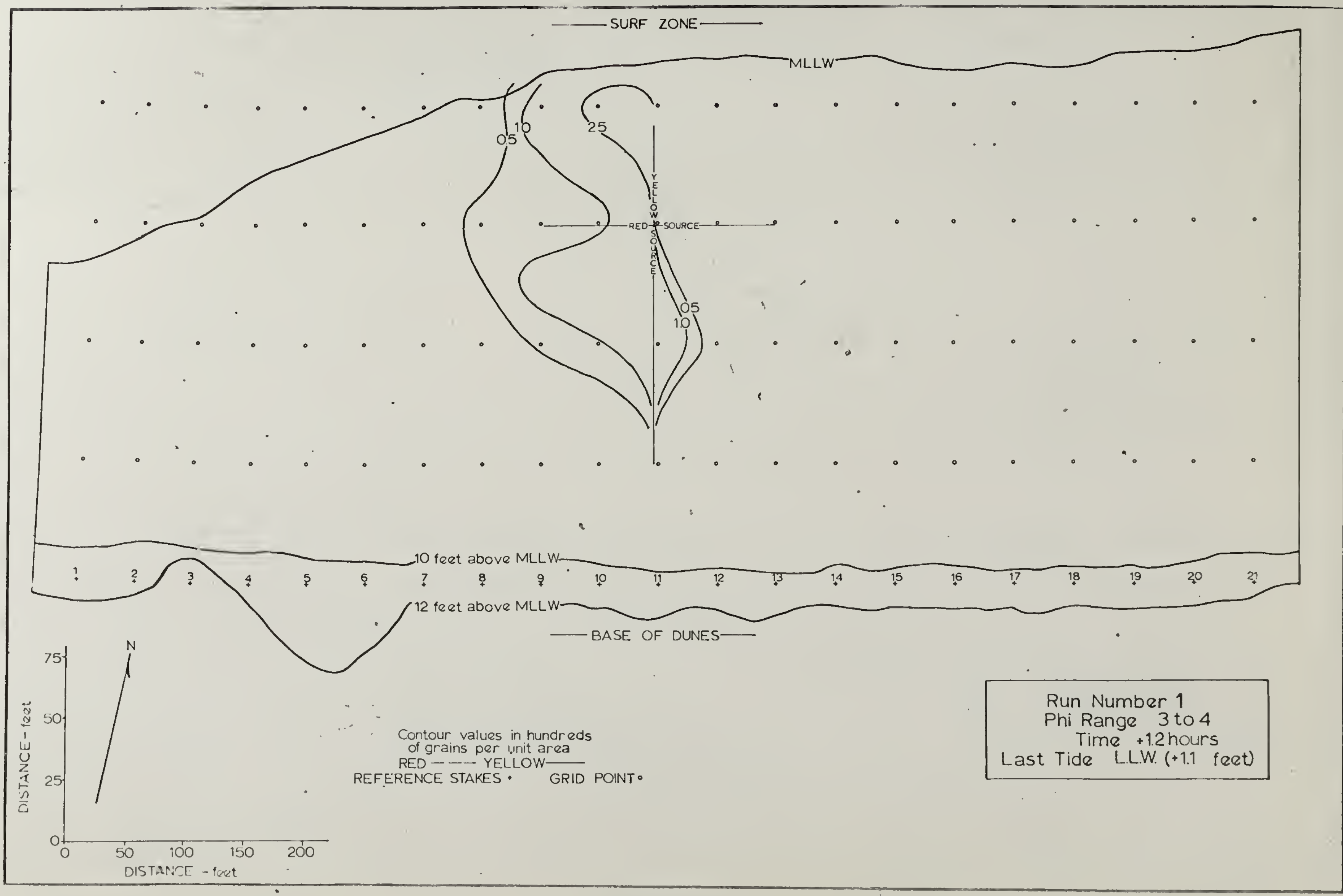


PLATE 5-1

MARKED SAND DISTRIBUTION

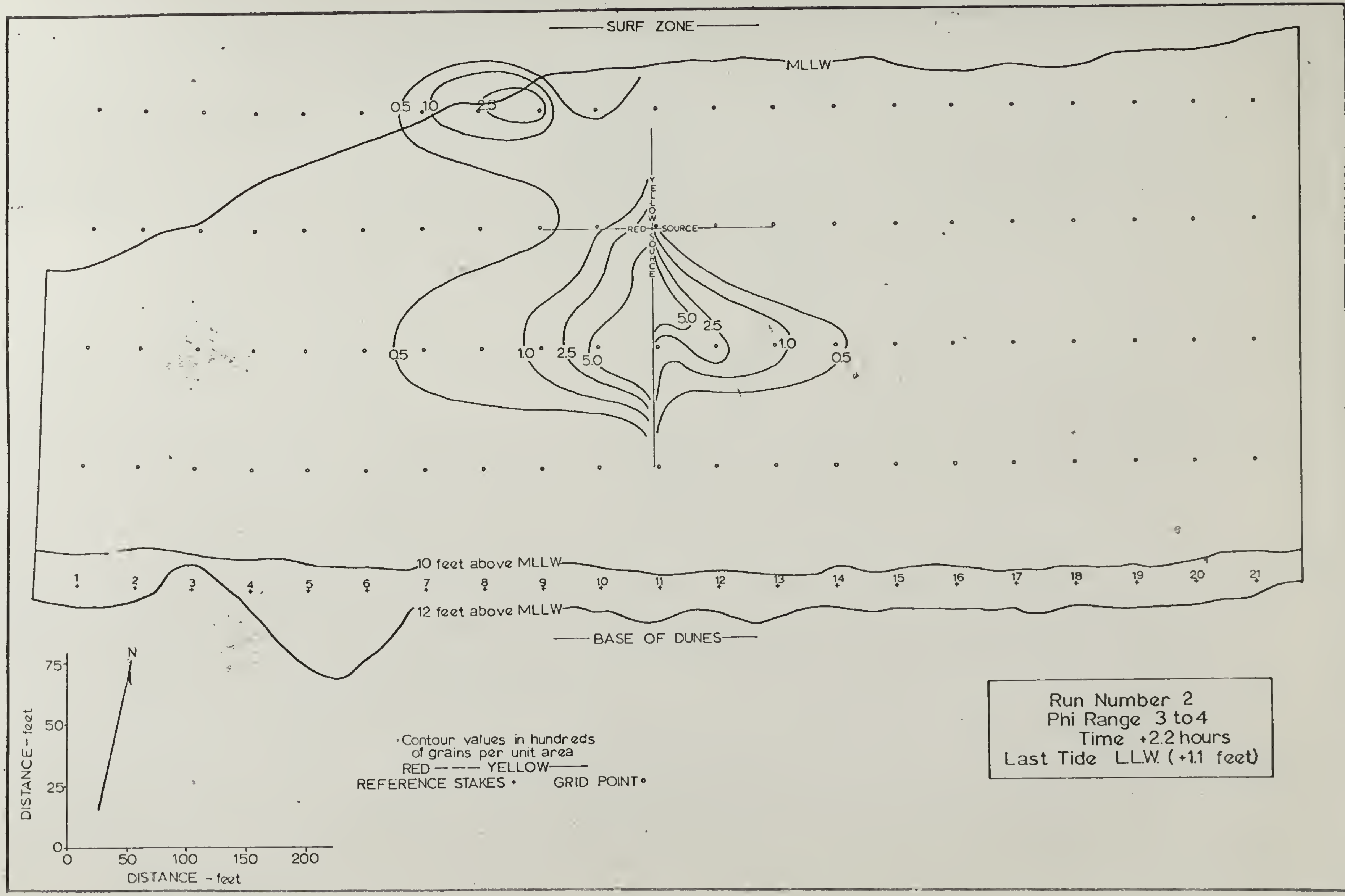


PLATE 5-2

MARKED SAND DISTRIBUTION

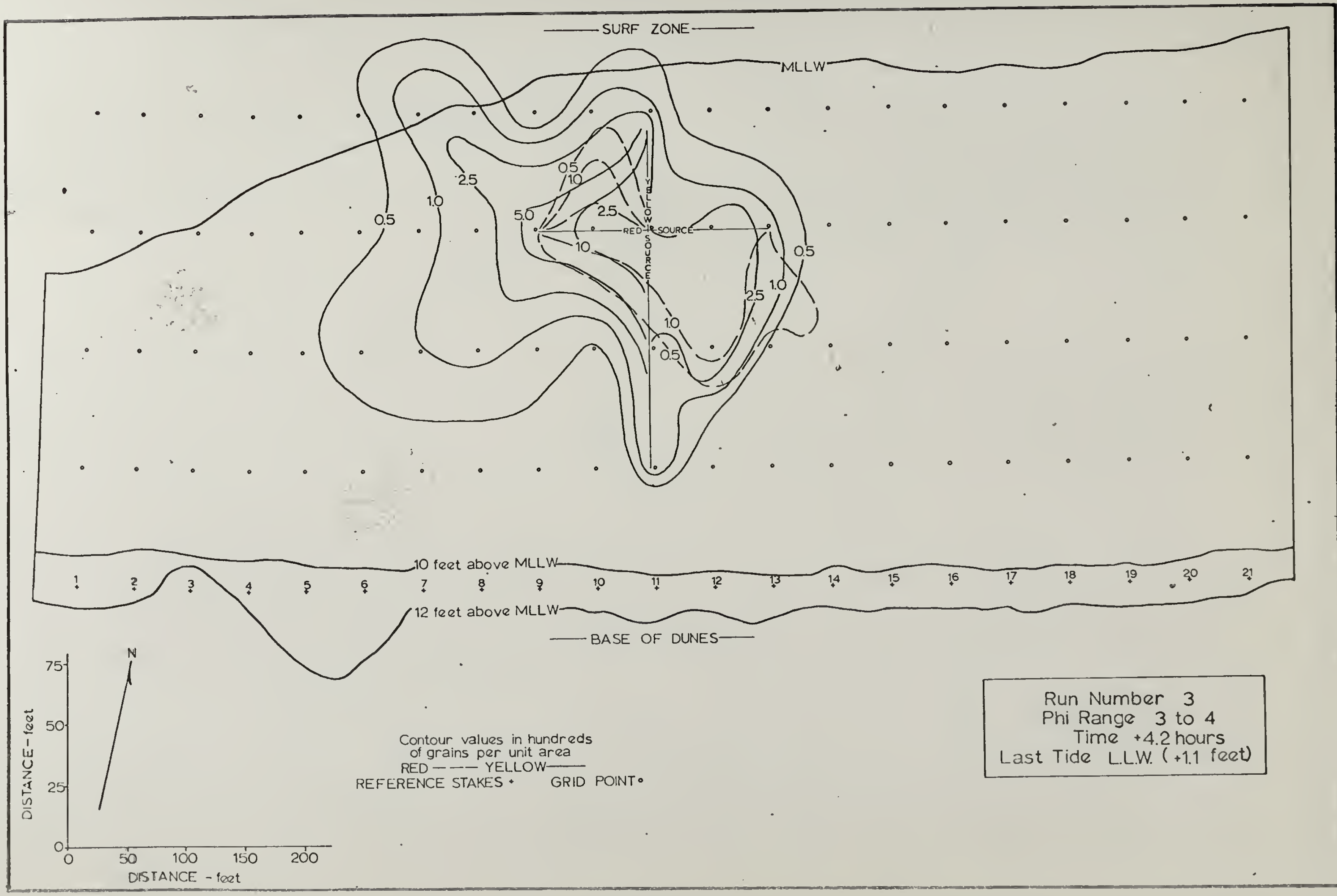


PLATE 5-3

MARKED SAND DISTRIBUTION

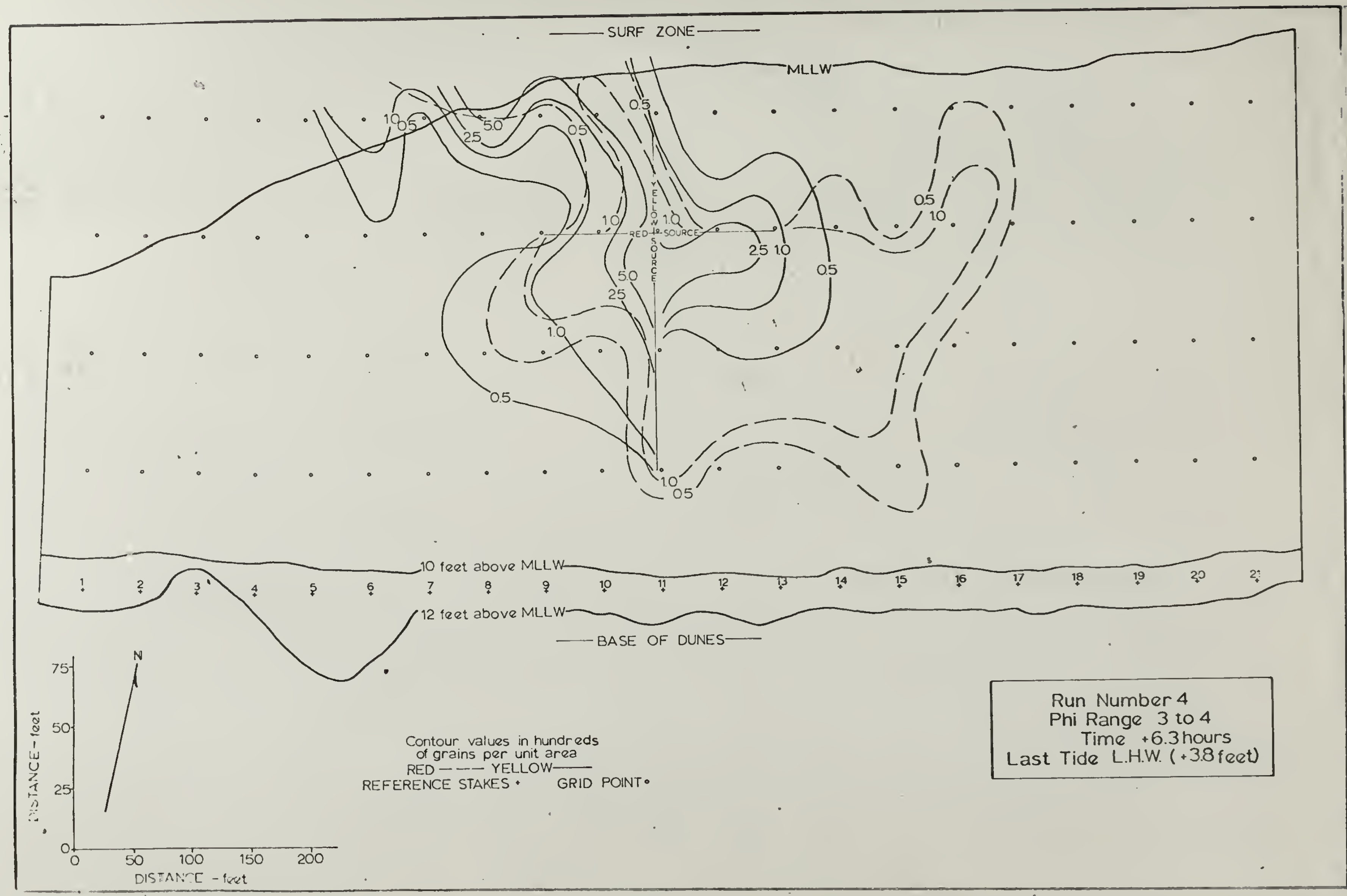


PLATE 5-4

MARKED SAND DISTRIBUTION

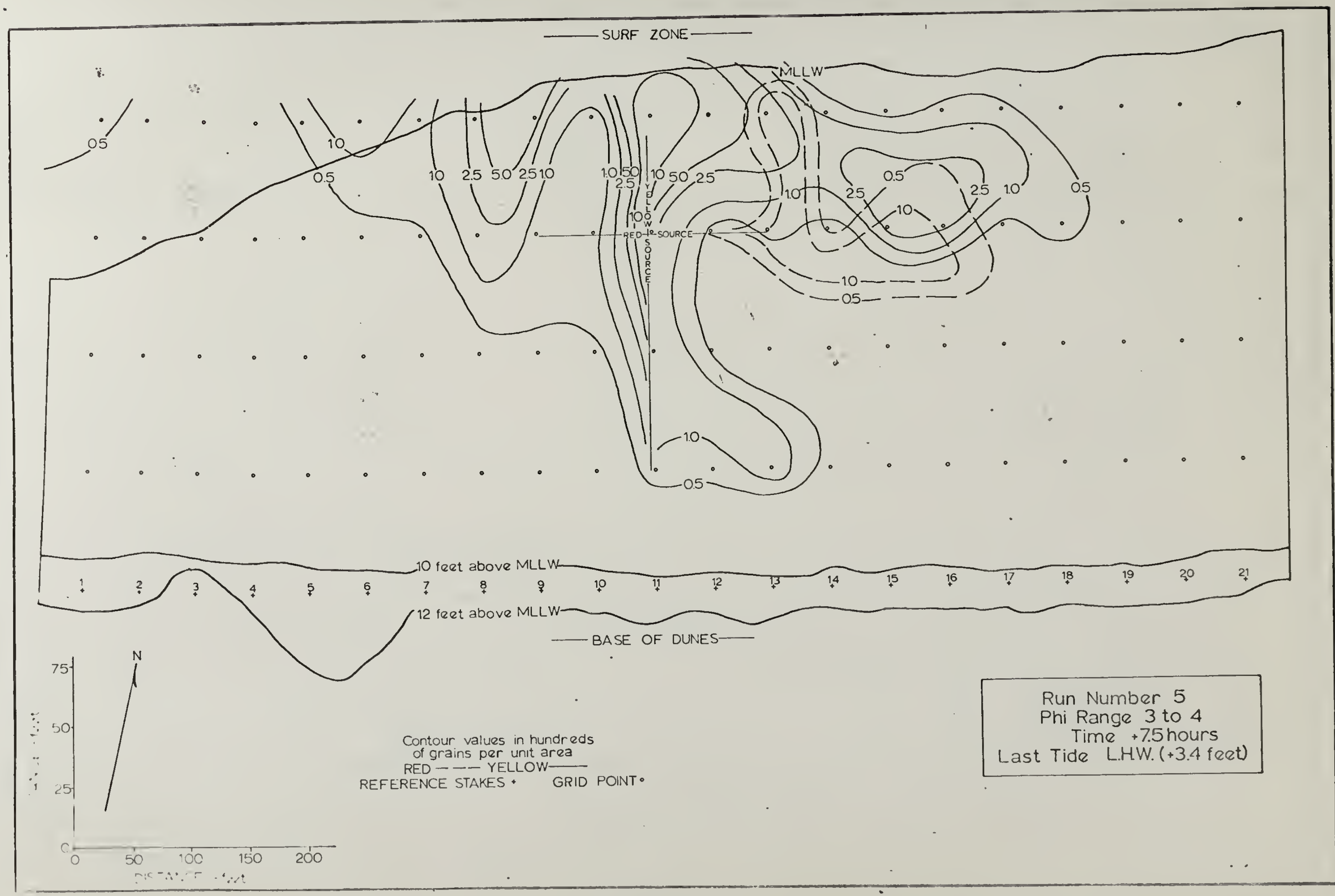


PLATE 5-5

MARKED SAND DISTRIBUTION

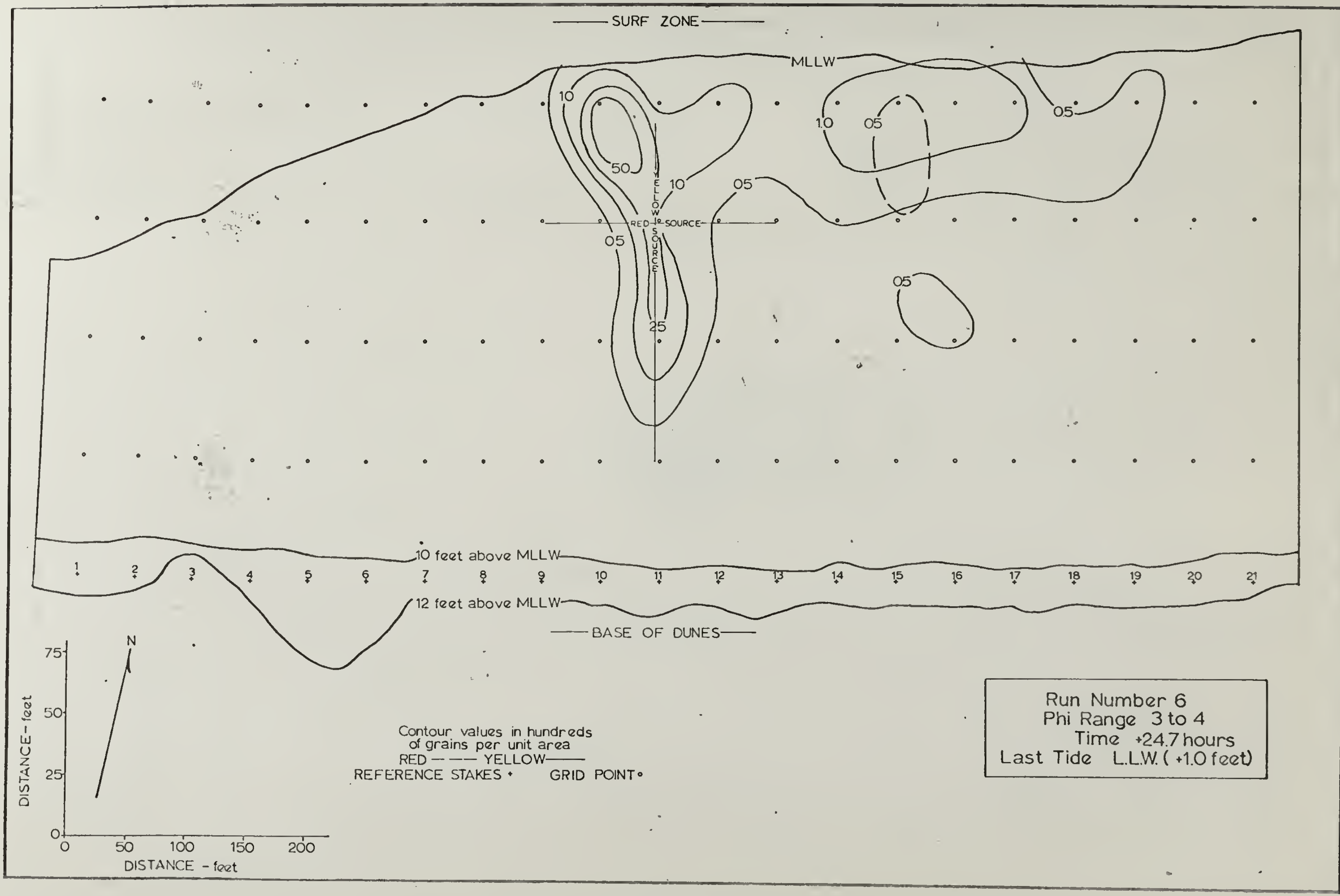


PLATE 5-6

MARKED SAND DISTRIBUTION

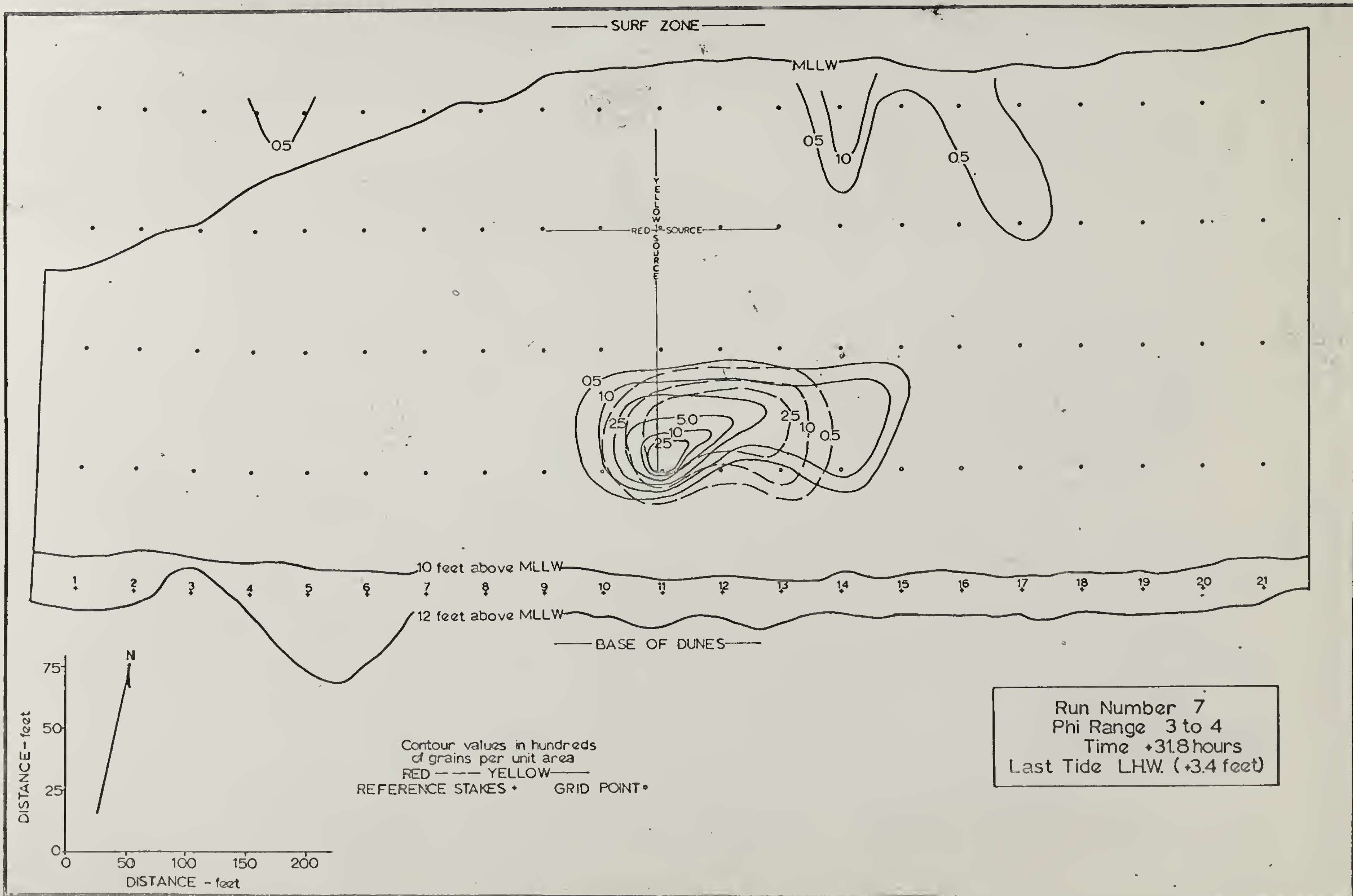


PLATE 5-7

MARKED SAND DISTRIBUTION

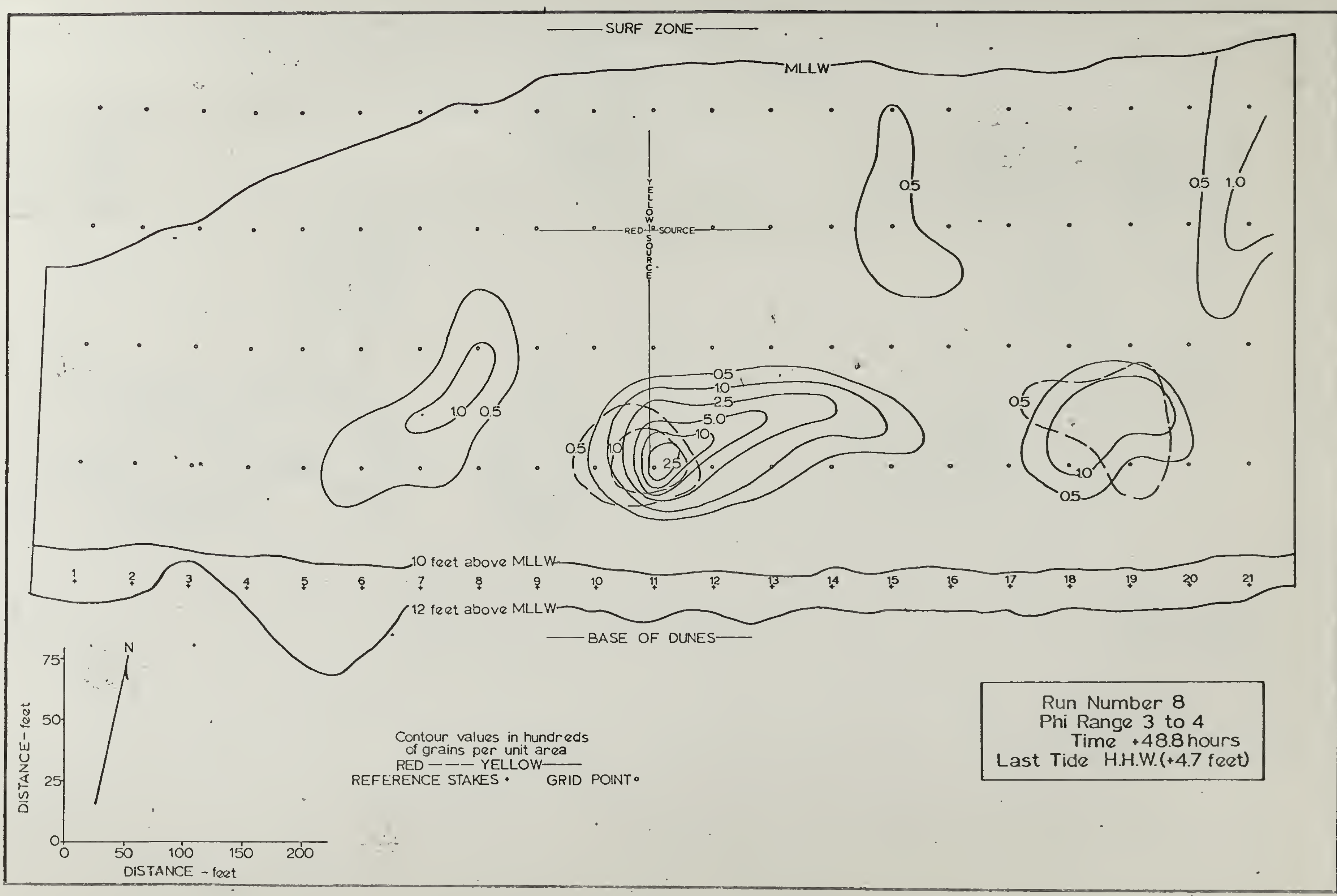


PLATE 5-8

MARKED SAND DISTRIBUTION

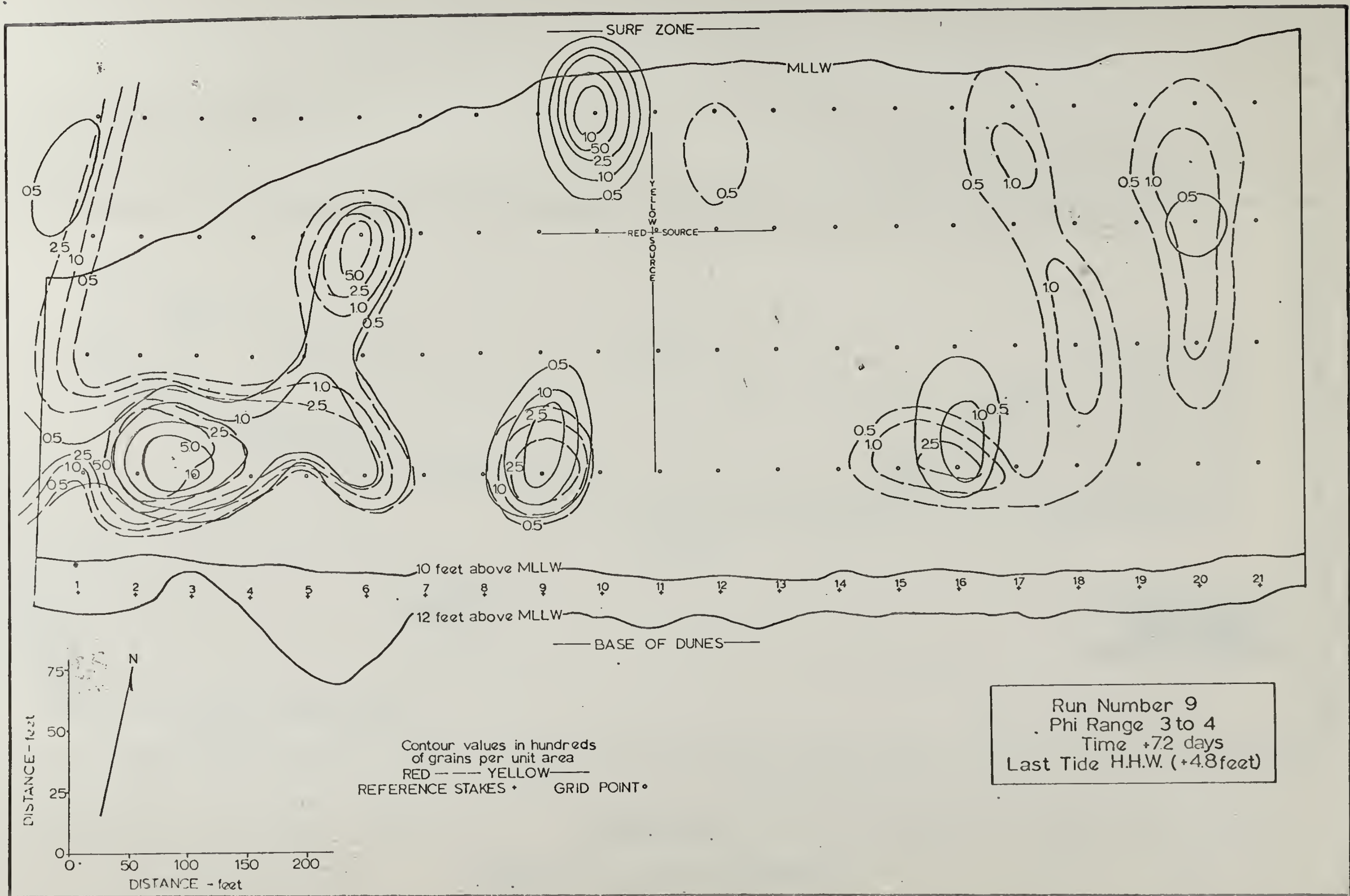


PLATE 5-9

MARKED SAND DISTRIBUTION

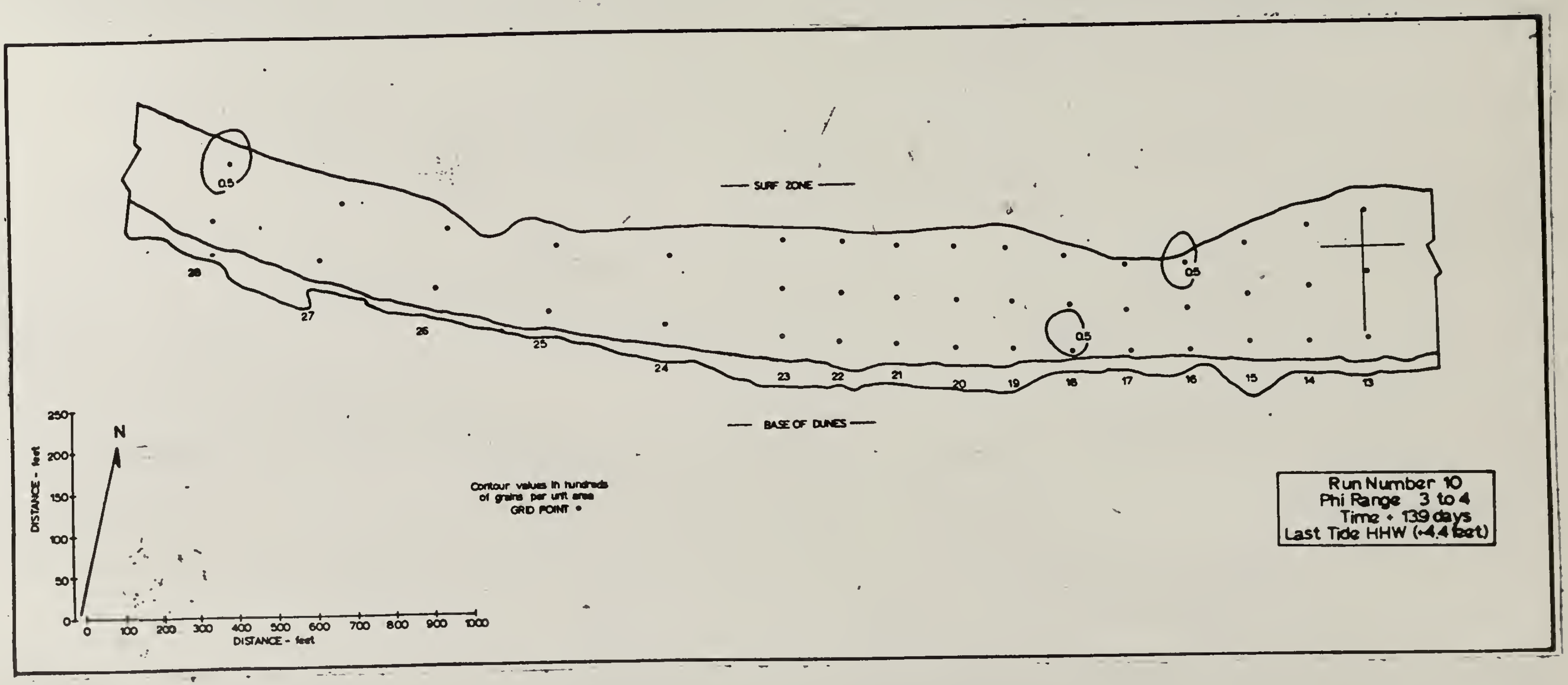


PLATE 5-10

MARKED SAND DISTRIBUTION